ANL EBRREG6

A R G O N N E   N A T I O N A L   L A B O R A T O R Y

IDAHO DIVISION

REPORT OF EBR-II OPERATIONS

October 1, 1966, through December 31, 1966

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IDAHO FALLS, IDAHO

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I. Operations

A. Summary

Three power runs, Nos. 22, 23, and 24, accounted for a total of 2366 MWdt which gives a plant factor of 57% for this quarter. 12,365 MWdt and 645 MWde have been accumulated since the start of power operation in July 1964.

The semiannual maintenance shutdown, which started at the end of August, was in progress during the early portion of this period. As the result of seal trough cleaning operations, about 160 pounds of oxidized alloy were removed and 477 pounds of Cerrotru alloy was added to bring both troughs back to their original level of about 8-1/2 in. The main turbine was reassembled and checkout of the modification to the secondary sodium piping trace heating system was in progress. The primary system had been cooled to 350°F to accomplish filling of the secondary sodium system. The new rotary reactivity oscillator was installed in control rod position No. 8 during this cool-down period. Sodium systems heat-up was initiated and continued until 700°F standby conditions were achieved.

Final reactor loading for Run No. 22 resulted in a 78-subassembly core, which included 8 experimental subassemblies. Before and during operations for fuel handling, the temperature control in the rotating plug seal troughs was greatly improved and free rotation was achieved in less than four hours. Run No. 22 started on October 19 and was completed on November 14.

Fuel handling started immediately after Run No. 22. Experimental subassembly X009 was removed and subassemblies X015 (structural samples) and X017 (PuO_2- UO_2 , PuC - UC and Mark IA metal) were inserted during this loading. This resulted in a 79-subassembly core including 9 experimental subassemblies.

An MI-type electrical penetration and a coaxial-type electrical penetration on the reactor building were modified to provide permanent double flanges for annual leak-rate testing. Campbelling experiments (Root-Mean-Square Voltage Test) using a startup fission chamber were conducted; the data look quite promising for expanding the useful range of the startup fission chambers.

Run No. 23 started November 16. Several of the control rods were calibrated and power coefficient measurements were made during the approach to power. Routine operations continued, except for power reduction to 30 MW to test the dynamic characteristics of the feedwater control valve and a power reduction to 40 MW to conduct reactor system lag-time measurements. The scheduled 690 MWd of operations for Run No. 23 was completed December 3.

Eighteen subassemblies were exchanged during fuel handling operations. Experimental subassemblies XA07, U-1550X and U-1551X were removed and X018 (structural samples) was installed. Rotation of the shield plugs was accomplished about four hours after the seal trough heaters were turned on. Run No. 24 started on December 9 with control rod calibrations and power coefficient measurements. On December 13 the rotary reactivity oscillator was started for the first time during 30 MW operation. Oscillator experiments continued on succeeding days at 20 MW and 500 kW. At certain reactor power-to-flow ratio changes, the Δt across the reactor changes and at powers above 30 MW with 100% flow, the drag became noticeable. Therefore, operation of the oscillator above that core Δt (~100°F)

were suspended. The data taken at 30 MW agreed with previous data obtained with the reciprocating oscillator.

The reactor was shut down on December 23 to obtain approval for operation with 10 control rods. This approval was necessary to install the stainless steel dummy control rod in control rod position No. 1; the oscillator remained in control rod position No. 8. The stainless steel control rod was used to obtain reactor kinetics measurements related to prompt power coefficient with the 81-subassembly core, before changing to the 91-subassembly core planned for Run No. 25. Operation resumed on the 29th and the kinetics data was obtained using the dummy in control rod position No. 1. The scheduled 630 MWd of operation for Run No. 24 were completed December 31.

B. Chronology of Principal Events

Date	Event
10/1/66	Semiannual plant shutdown in progress for maintenance and modification, plus major turbine inspection and overhaul. Primary sodium system at 398°F and cooldown in progress. Primary tank heaters off and shutdown coolers open. Secondary sodium system drained to storage tank.
10/2	Primary sodium system cooled to 350°F. Total power outage caused by incoming line failure.
10/4	Conducted test of reactor building isolation system.
10/5	Performed tests on the instrument-thimble-cooling system.
10/6	Began heat up of secondary sodium piping and steam system.
10/7	Filled secondary sodium piping system.
10/8	Rotary oscillator rod installed in control rod position No. 8.
10/9	Began plant heatup to 500°F.
10/10	Primary sodium 500°F. Conducted tests on instrument thimble heatup rates.
10/11	Continued plant heatup to 700°F.
10/14	Primary system at 700°F standby.
10/16	Power outage due to incoming line severe voltage oscillations.
10/17	Completed cleaning seal troughs and added make-up Cerrotru alloy.
10/18	Began unrestricted fuel handling in preparation for Run No. 22.
10/19	Removed stainless steel dummy control rod and replaced with a standard control rod and changed one inner blanket driver subassembly

B. Chronology of Principal Events (cont'd)

Date	Event
12/5/66	Removed experimental subassemblies XA07, U-1550X and U-1551X from reactor.
12/6	Installed experimental subassembly X018 in reactor.
12/6	Completed unrestricted fuel handling.
12/9	Reactor startup for Run No. 24.
12/9	Calibrated control rods No. 2, 6, and 9.
12/10	Took power coefficient measurements during approach to power. Checked turbine overspeed trips. Synchronized generator with NRTS loop.
12/13 - 12/16	Reduced reactor power to 30 MW for oscillator experiments.
12/19	Reduced reactor power for oscillator experiments.
12/20	Reduced reactor power to 500 kW for oscillator experiments.
12/20	Reduced reactor power to 20 MW and primary flow to 52% flow for oscillator experiments.
12/23	Shut down reactor and set up rod-drop circuit for control rod No. 1.
12/23	Started back up to power.
12/24	Shut down reactor to obtain approval to use stainless steel dummy control rod in position No. 1.
12/28	Began unrestricted fuel handling to install stainless steel dummy control rod in control rod position No. 1.
12/29	Started up reactor (Run No. 24 - continued) and calibrated stainless steel control rod. Performed rod drops with control rod No. 1.
12/29	Reactor at 45 MW.
12/29	Reduced power to 30 MW for oscillator experiments.
12/30	Performed rod oscillator experiments at various powers and flows.
12/31	Shut down reactor to complete Run No. 24 after 630 MWd operation.
12/31	Plant status -- plant standby at 700°F.

C. Plant Performance

1. Power

Power production in October, November, and December is presented in Figures 1 through 9.

Detailed power production data are provided in Tables I, II, and III.

2. Systems and Components

Scrams from power level 1 MW or greater are summarized in Table IV.

Primary sodium flow and pump performance are presented in Figures 10 through 15. Similar information for the secondary sodium pump is given in Figures 16 through 18.

Steam header temperature and pressure are plotted in Figures 19 through 21, principally for future reference with regard to water treatment, steam generation, etc.

3. Steady State Subassembly Outlet Temperatures

The plots of subassembly outlet temperature are presented in Figures 22 through 30. In place of the plots for four representative thermocouples included in previous reports, the data from all 21 thermocouples are plotted. The computer program has been revised to calculate the average value for each day while the reactor is at full power. Although not included in the plots, the maximum and minimum values and standard deviation are also computed. This gives a more thorough analysis using all available data.

During any single run, the temperature for each thermocouple remained constant (within $\pm$ 2°F). The changes from run to run are due to reactor loading changes.

The loading changes have effects that can be divided into three catagories. (1) Flow distribution changes result from changes in core size. Fueled assemblies require more cooling and, therefore, when a driver subassembly is substituted for a blanket subassembly, there is a decrease in flow in the remaining core positions to compensate for the increased flow in the core position where the loading change was made. (2) There is a general change in flux distribution. (3) The local flux changes in the core position where the loading change has been made and in adjacent core positions.

4. Sodium and Argon Chemistry

a. Primary Argon

The activities of Argon-41, Xenon-133, and Xenon-135 measured in samples of the primary cover gas are plotted in Figures 31, 32, and 33.

TABLE I

OPERATING HISTORY DATA
October, 1966

Date	Reactor Critical Time	Cumulative Critical Time	Gross Thermal Energy	Cumulative Gross Thermal Energy	Gross Electrical Energy	Cumulative Gross Electrical Energy	Generator on Time	Cumulative Generator on Time	Thermal Power Range Max.	Thermal Power Range Min.
	Hrs	Hrs	MWht	MWht	MWhe	MWhe	Hrs	Hrs	MW	MW
1	0	6968.0	0	237120	0	61848	0	4743.6	0	0
2	0	6968.0	0	237120	0	61848	0	4743.6	0	0
3	0	6968.0	0	237120	0	61848	0	4743.6	0	0
4	0	6968.0	0	237120	0	61848	0	4743.6	0	0
5	0	6968.0	0	237120	0	61848	0	4743.6	0	0
6	0	6968.0	0	237120	0	61848	0	4743.6	0	0
7	0	6968.0	0	237120	0	61848	0	4743.6	0	0
8	0	6968.0	0	237120	0	61848	0	4743.6	0	0
9	0	6968.0	0	237120	0	61848	0	4743.6	0	0
10	0	6968.0	0	237120	0	61848	0	4743.6	0	0
11	0	6968.0	0	237120	0	61848	0	4743.6	0	0
12	0	6968.0	0	237120	0	61848	0	4743.6	0	0
13	0	6968.0	0	237120	0	61848	0	4743.6	0	0
14	0	6968.0	0	237120	0	61848	0	4743.6	0	0
15	0	6968.0	0	237120	0	61848	0	4743.6	0	0
16	0	6968.0	0	237120	0	61848	0	4743.6	0	0
17	0	6968.0	0	237120	0	61848	0	4743.6	0	0
18	0	6968.0	0	237120	0	61848	0	4743.6	0	0
19	5.2	6973.2	0	237120	0	61848	0	4743.6	12.5	0
20	9.8	6983.0	50	237170	0	61848	0	4743.6	25	0
21	19.5	7002.5	655	237825	0	61848	0	4743.6	45	0
22	24.0	7026.5	1080	238905	70	61918	5.4	4749.0	45	45
23	24.0	7050.5	1080	239985	320	62238	24.0	4773.0	45	45
24	24.0	7074.5	1066	241051	312	62550	24.0	4797.0	45	35
25	23.0	7097.5	1035	242086	313	62863	23.0	4820.0	45	0
26	17.5	7115.0	689	242775	213	63076	12.6	4832.6	45	0
27	24.0	7139.0	1078	243853	326	63402	24.0	4856.6	45	40
28	24.0	7163.0	1080	244933	326	63728	24.0	4880.6	45	45
29	24.0	7187.0	1080	246013	326	64054	24.0	4904.6	45	45
30	24.0	7211.0	1076	247089	258	64312	24.0	4928.6	45	35
31	24.0	7235.0	1080	248169	324	64636	24.0	4952.6	45	45

TABLE II

OPERATING HISTORY DATA

November, 1966

Date	Reactor Critical Time	Cumulative Critical Time	Gross Thermal Energy	Cumulative Gross Thermal Energy	Gross Electrical Energy	Cumulative Gross Electrical Energy	Generator on Time	Cumulative Generator on Time	Thermal Power Range Max.	Thermal Power Range Min.
	Hrs	Hrs	MWht	MWht	MWhe	MWhe	Hrs	Hrs	MW	MW
1	24.0	7259.0	1080	249249	324	64960	24.0	4976.6	45	45
2	24.0	7283.0	1080	250329	325	65285	24.0	5000.6	45	45
3	24.0	7307.0	1080	251409	325	65610	24.0	5024.6	45	45
4	24.0	7331.0	1070	252479	318	65928	24.0	5048.6	45	41
5	24.0	7355.0	1080	253559	325	66253	24.0	5072.6	45	45
6	24.0	7379.0	1080	254639	325	66578	24.0	5096.6	45	45
7	24.0	7403.0	1079	255718	322	66900	24.0	5120.6	45	41
8	24.0	7427.0	1068	256786	320	67220	24.0	5144.6	45	30
9	24.0	7451.0	1080	257866	325	67545	24.0	5168.6	45	45
10	24.0	7475.0	1080	258946	325	67870	24.0	5192.6	45	45
11	24.0	7499.0	1060	260006	225	68095	17.0	5209.6	45	30
12	24.0	7523.0	1080	261086	325	68420	24.0	5233.6	45	45
13	24.0	7547.0	1080	262166	325	68745	24.0	5257.6	45	45
14	2.4	7549.4	45	262211	12	68757	1.1	5258.7	45	0
15	0.6	7550.0	0	262211	0	68757	0	5258.7	50	0
16	11.7	7561.7	9	262220	0	68757	0	5258.7	10	0
17	24.0	7585.7	985	263205	237	68994	18.5	5277.2	45	10
18	21.0	7606.7	756	263961	170	69164	14.8	5292.0	45	0
19	24.0	7630.7	1075	265036	326	69490	24.0	5316.0	45	37.5
20	24.0	7654.7	1080	266116	326	69816	24.0	5340.0	45	45
21.	24.0	7678.7	1080	267196	323	70139	24.0	5364.0	45	45
22	24.0	7702.7	1080	268276	324	70463	24.0	5388.0	45	45
23	24.0	7726.7	1020	269296	307	70770	24.0	5412.0	45	10
24	24.0	7750.7	1080	270376	324	71094	24.0	5436.0	45	45
25	24.0	7774.7	1080	271456	324	71418	24.0	5460.0	45	45
26	24.0	7798.7	1080	272536	324	71742	24.0	5484.0	45	45
27	24.0	7822.7	1080	273616	324	72066	24.0	5508.0	45	45
28	24.0	7846.7	1080	274696	261	72327	24.0	5532.0	45	45
29	22.0	7868.7	897	275593	248	72575	19.0	5551.0	45	0
30	24.0	7892.7	1080	276673	317	72892	24.0	5575.0	45	45

TABLE III

OPERATING HISTORY DATA
December, 1966

Date	Reactor Critical Time	Cumulative Critical Time	Gross Thermal Energy	Cumulative Gross Thermal Energy	Gross Electric Energy	Cumulative Gross Electrical Energy	Generator on Time	Cumulative Generator on Time	Thermal Power Range Max.	Thermal Power Range Min.
	Hrs	Hrs	MWht	MWht	MWhe	MWhe	Hrs	Hrs	MW	MW
1	22.0	7914.7	971	277644	276	73168	21.5	5596.5	45	0
2	24.0	7938.7	1066	278710	320	73488	24.0	5620.5	45	40
3	1.5	7940.2	61	278771	15	73503	1.3	5621.8	45	0
4	0	7940.2	0	278771	0	73503	0	5621.8	0	0
5	0	7940.2	0	278771	0	73503	0	5621.8	0	0
6	0	7940.2	0	278771	0	73503	0	5621.8	0	0
7	0	7940.2	0	278771	0	73503	0	5621.8	0	0
8	0	7940.2	0	278771	0	73503	0	5621.8	0	0
9	7.5	7947.7	2	278773	0	73503	0	5621.8	.5	0
10	20.0	7967.7	428	279201	72	73575	7	5628.8	45	0
11	24.0	7991.7	1080	280281	324	73899	24.0	5652.8	45	45
12	24.0	8015.7	986	281267	287	74186	24.0	5676.8	45	30
13	24.0	8039.7	975	282242	285	74471	24.0	5700.8	45	30
14	24.0	8063.7	848	283090	251	74722	20.5	5721.3	45	1.3
15	24.0	8087.7	833	283923	262	74984	19.0	5740.3	45	1
16	24.0	8111.7	997	284920	309	75293	24.0	5764.3	45	30
17	23.0	8134.7	915	285835	284	75577	19.5	5783.8	45	0
18	24.0	8158.7	1080	286915	324	75901	24.0	5807.8	45	45
19	23.0	8181.7	904	287819	280	76181	22.0	5829.8	45	30
20	24.0	8205.7	522	288341	137	76318	11.0	5840.8	45	0.5
21	24.0	8229.7	853	289194	242	76562	24.0	5864.8	45	20
22	24.0	8253.7	1070	290264	232	76794	24.0	5888.8	45	41
23	21.0	8274.7	754	291018	272	77066	18.0	5906.8	45	0
24	18.3	8293.0	713	291731	257	77323	14.7	5921.5	45	0
25	0	8293.0	0	291731	0	77323	0	5921.5	0	0
26	0	8293.0	0	291731	0	77323	0	5921.5	0	0
27	0	8293.0	0	291731	0	77323	0	5921.5	0	0
28	0	8293.0	0	291731	0	77323	0	5921.5	0	0
29	22.8	8315.8	348	292079	0	77323	0	5921.5	45	0
30	24.0	8339.8	1036	293115	0	77323	0	5921.5	45	20
31	18.5	8358.3	776	293891	0	77323	0	5921.5	45	0

TABLE IV

SUMMARY OF EBR II SCRAMS FROM POWER

October 1 through December 31, 1966

Month	Day	Time	Power Level	Trip	Remarks
October	20	1900	5 MW	Bulk sodium level low	* Instrument malfunction
October	21	0635	45 MW	Reactor inlet coolant low flow #1 or #2	Noise signal caused by intermittent fault in converter
October	21	1155	1 MW	Bulk sodium level low	* Instrument malfunction
October	25	2300	45 MW	Reactor inletcoolant (H.P. #1 or #2) flow rate of change high	** Noise signal from feedwater pump transfer relay
November	18	1420	45 MW	Reactor outlet coolant temperature high	** Noise signal from feedwater pump transfer relay
November	29	0108	45 MW	Reactor inlet coolant (L.P. #2) low flow	Instrument malfunction; cause not determined
December	1	0917	45 MW	Reactor outlet coolant flow low	Trip occurred when a primary flow recorder was removed from secondary panel
December	10	0540	20 MW	Bulk sodium temperature high	Noise pulse while setting core subassembly temperature trips
December	10	0705	10 MW	Bulk sodium temperature high	Noise pulse while setting core subassembly temperature trips
December	10	1350	45 MW	Reactor outlet coolant temperature high	Noise signal while setting core subassembly temperature trips
December	10	1546	20 MW	Bulk sodium level low	* Instrument malfunction
December	17	0425	23 MW	Bulk sodium level low	* Instrument malfunction
December	19	0242	45 MW	Reactor inlet coolant (H.P. #1 or #2) flow rate of change high	Apparent instrument malfunction caused by vacuum tube failure pump #2 amplifier
December	24	0646	10 MW	Bulk sodium level low	* Apparent instrument malfunction
December	29	1242	22.5 MW	Manual Scram	Lost feedwater pump due to loss of control power

* A replacement sodium level system is on order with delivery anticipated in the latter part of February, 1967. The malfunctioning component is not accessible for immediate repair

** The transfer relay was delayed on reset to eliminate relay chatter causing the noise signal

Results of analysis of primary cover gas by the laboratory chromatograph are summarized on a monthly basis below:

	Hydrogen (ppm vol.)		Nitrogen (v/o)	
	Range	Average	Range	Average
October 1966	3 - 125	less than 10	0.4 - 2.0	1.39
November 1966	0 - 100	20	0.7 - 1.3	0.95
December 1966	13 - 400	less than 100	0.52 - 1.1	0.71

The on-line gas chromatograph for continuous analysis of hydrogen and nitrogen in the primary cover gas was put into operation at the end of the quarter.

b. Primary Sodium

The following apparent plugging temperatures were measured during October 1966.

Date	Shift	Plugg. Temp. °F
10/20/66	Afternoon	260
10/25/66	Night	295
10/26/66	Night	305, 310
10/26/66	Day	297

Plugging temperatures and purification system flow for November are plotted in Figure 24.

All plugging temperatures in December were reported less than 240°F, with most measurements reported less than 230°F.

Samples of EBR-II primary sodium were analyzed for hydrogen and oxygen content by analysts in ANL Chemistry Division, Metallurgy Division, and Idaho Division. Available results for the quarter, as well as results for three samples taken in September, are tabulated below:

Date Sampled	Hydrogen (ppm, wt)	Oxygen (ppm, wt)	Division Reporting
9/29/66	3.2, 5.6	5, 6	CHEM
9/30/66		6, 6	CHEM
9/30/66		23, 24	MET
12/ 2/66		13, 16, 18	ID
12/ 9/66		12, 15, 20	ID

Analysis results for several other samples taken during the quarter are not yet available. They will be included in the next quarterly report.

c. Secondary Argon

The continuous gas chromatograph, analyzing the argon from the surge tank, showed approximately 5 ppm (vol.) hydrogen and 1,000 to 1,200 ppm (vol.) nitrogen.

d. Secondary Sodium

Samples of the secondary sodium were analyzed by the ANL Chemistry Division. The results follow:

Date Sampled	Hydrogen (ppm, wt.)	Oxygen (ppm, wt.)
9/21/66	5.9, 5.9	15, 17
10/27/66	5.2, 4.8	7, 14

The secondary sodium plugging temperature and purification system operation are presented in Figures 35, 36, and 37.

5. Water Treatment

a. Power Cycle Streams

Data are tabulated below for power operation and for hot standby with feedwater and blowdown flow.

Stream	pH		Hydrazine (ppm)	
	Range	Average	Range	Average
Feedwater	9.0 - 10.1	9.6	0.04 - 0.2	0.1
Condensate	8.8 - 10.0	9.4		
Blowdown	8.9 - 9.7	9.4	0.04 - 0.3	0.2
Blowdown Demineralizer Effluent	5.9 - 8.7	7.8		
Steam	8.6 - 9.7	9.5		
Deaerator Effluent	9.2 - 10.0	9.6		

b. Cooling Water

Chemical treatment data for the quarter are tabulated below:

pH		Chromate (ppm CrO_4)		Approx. "Cycles of Concentration"*	
Range	Ave.	Range	Ave.	Range	Ave.
5.6 - 8.3	6.8	4.6 - 19.7	12.0	1.1 - 2.9	2.5

During the quarter, the cooling water pH was below 5.8 for a total of about 40 hours. The lowest pH value recorded was 3.8.

II. Fuel Handling

The maximum utilization of the fuel available consistent with the 1.2 a/o maximum burnup limitation for the Mark IA fuel continues as the primary objective. Fuel utlization related to 1.2 a/o maximum burnup has averaged 94.5%.

Three reactor power runs for a total of 2366 MWd have been completed to realize a plant factor of 57%.

Experimental Irradiations

Three experimental subassemblies were installed in the reactor in November and December. All three contained prototype oxide, carbide, and metal fuels (X015, X017, and X018). Two alpha measurement subassemblies which were irradiated in Rows 13 (U-1550X) and 15 (U-1551X) were removed from the reactor for examination.

The irradiation of experimental subassemblies X007 and X009 was completed and they were removed from the reactor. The irradiated experimental subassemblies (X007, X009, and X013) and four irradiated alpha measurement subassemblies (U-1448X, U-1449X, U-1550X, and U-1551X) were transferred to the Fuel Cycle Facility for disassembly.

Subassembly Inventory

A total of forty-three subassemblies which include thirty-one spent subassemblies, five subassemblies with high iron content, and seven experimental subassemblies were transferred to the Fuel Cycle Facility for examination, disassembly, and reprocessing of the spent subassemblies.

Thirty reprocessed subassemblies were received from the Fuel Cycle Facility for installation in the reactor.

The available inventory of subassemblies was exhausted by the loading requirements for power Runs 22, 23, and 24. A total of forth-eight subassemblies were required for these three loadings.

Fifteen subassemblies were available in inventory on October 1 and eight were available on December 31.

Grid Loading Changes

Three major changes in the reactor grid loadings were made for power Runs No. 22, 23, and 24. A check was made prior to Run No. 24 on nine outer blanket

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* Calculated as the ratio: $\dfrac{\text{Specific Conductance of Treated Circulating Water at } 25^\circ C}{\text{Specific Conductance of Make-up Water at } 25^\circ C}$

subassemblies located in positions in Rows 8 through 16 by lifting and returning them to their original position. Each of the subassemblies checked moved freely out of and into each position.

A summary of the loadings of the core is given below:

Reactor Power Run No.	Core Size	Experimental Irradiation Subassemblies
22	80	7 in core, 4 in inner blanket
23	79	8 in core, 4 in inner blanket
24	81	7 in core, 4 in inner blanket

Fuel Utilization

The average utilization of the fuel related to 1.2 a/o maximum burnup in the spent subassemblies removed after Runs No. 22, 23, and 24 and also in the spent subassemblies transferred to the Fuel Cycle Facility is summarized as follows:

Power Run No.	Spent Subassemblies Removed from Reactor	% Fuel Utilization
22	15	94
23	10	94.5
24	13	94.5
Thirty-one spent subassemblies transferred to Fuel Cycle Facility		95

TABLE V

LOADING CHANGES FOR RUN NO. 22

Subassembly No.	From	To	Maximum Burnup (Calculated)
X013	3C1		----
C264		3C1	
C227	3A2		0.912
C263		3A2	
C231	3F2		1.10
C266		3F2	
C199	4B1		1.20
C267		4B1	
C216	4C1		1.20
C268		4C1	
C218	4E1		1.20
C269		4E1	
C214	5C2		1.099
C273		5C2	
C224	5C4		1.099
C274		5C4	
L428	5E3		1.025
L441		5E3	
B318	6A2		0.956
B344		6A2	
B317	6A4		1.187
B345		6A4	
B323	6B3		1.187
B340		6B3	
B336	6C2		.33
A724		6C2	
B328	6C3		1.187
B336		6C3	.33
B330	6D3		1.06
A720		6D3	
B329	6D4		1.187
B319		6D4	
B322	6F3		1.187
A764		6F3	
L429	5A3		1.063
Oscr. Rod		5A3	
SSC-Rod	5B1		
L429		5B1	
B327	6F4		1.19
B341		6F4	
A764	6F3		
B347		6F3	

TABLE VI

LOADING CHANGES FOR RUN NO. 23

Subassembly No.	From	To	Maximum Burnup (Calculated)
C237	1A1		1.00
C219		1A1	
C246	2C1		0.956
C270		2C1	
X009	4A2		3.2
X015		4A2	
C228	4A3		1.154
C227		4A3	
C229	4B3		1.195
C271		4B3	
C230	4C3		1.182
X017		4C3	
C232	4D1		1.109
C272		4D1	
C235	4E3		1.18
C275		4E3	
C233	4F1		1.109
C276		4F1	
L429	5B1		1.06
L428		5B1	
C234	5B4		1.01
C277		5B4	
B331	6A3		1.184
B326		6A3	
A720	6D3		
B348		6D3	
A752	7A3		
A730		7A3	
U1124	12E6		
U1029		12E6	

TABLE VII

LOADING CHANGES FOR RUN NO. 24

Subassembly No.	From	To	Maximum Burnup (Calculated)
C219	1A1		0.25
C283		1A1	
C249	3B2		1.19
C257		3B2	
C250	3D2		1.19
C219		3D2	0.25
C241	4A1		1.05
C262		4A1	
C227	4A3		1.15
C278		4A3	
XA07	4D3		4.95
C282		4D3	
C251	4F3		1.08
C246		4F3	
L428	5B1		1.20
L445		5B1	
L430	5D3		1.15
L442		5D3	
L431	5F3		1.15
L443		5F3	
B332	6E4		1.16
B349		6E4	
B326	6A3		1.09
B350		6A3	
U1550X	13B7		
U1545		13B7	
U1551X	15B8		
U1118		15B8	
S607	3D1		1.145
S605		3D1	
C253	2B1		0.949
X018		2B1	
C242	3F1		1.175
C253		3F1	
A758	6D2		
B351		6D2	
A701	6A5		
B353		6A5	
L437	5D1		0.59
CRD-SST		5D1	

(Continued)

TABLE VII
(Continued)

LOADING CHANGES FOR RUN NO. 24

Subassembly No.	From	To	Maximum Burnup (Calculated)
Outer Blanket Subassembly Check			
U1402	8A3		
U1402		8A3	
U1120	9B4		
U1120		9B4	
U1492	10C5		
U1592		10C5	
U1353	11D5		
U1353		11D5	
U1413	12E5		
U1413		12E5	
U1328	13F5		
U1328		13F5	
U1067	14A6		
U1067		14A6	
U1201	15B7		
U1201		15B7	
U1526	16C9		
U1526		16C9	

TABLE VIII

SUBASSEMBLIES TRANSFERRED TO AND FROM FCF

Spent Subassemblies Transferred to FCF

Subassembly No.	Grid Position	Maximum Burnup	Date
C227	4A3	1.15	12-21-66
C228	4A3	1.155	12-13-66
C229	4B3	1.195	12- 6-66
C230	4C3	1.182	12- 9-66
C232	4D1	1.11	12-10-66
C233	4F1	1.11	12-12-66
C234	5B4	1.02	12-13-66
C235	4E3	1.18	12-14-66
C241	4A1	1.05	12-20-66
C242	3F1	1.175	12-20-66
C249	3B2	1.190	12-16-66
C250	3D2	1.190	12-17-66
C251	4F3	1.08	12-19-66
*C279	---	----	11-29-66
*C280	---	----	11-30-66
*C281	---	----	12- 1-66
*C284	---	----	12- 2-66
*C285	---	----	12- 5-66
B322	6F3	1.187	11-17-66
B326	6A3-6C5	1.09	12-27-66
B327	6F4	1.19	11-28-66
B328	6C3	1.187	11-18-66
B329	6D4	1.187	11-21-66
B330	6D3	1.06	11-22-66
B331	6A3	1.19	12-23-66
B332	6E4	1.16	12-27-66
L421	5C1	1.16	11- 8-66
L423	5D1	1.16	11- 9-66
L424	5E1	1.16	11-11-66
L425	5F1	1.16	11-14-66
L426	5A1	1.08	11-15-66
L427	5B3	1.08	11-16-66
L428	5B1	1.20	12-28-66
L429	5B1	1.06	12-28-66
L430	5C3	1.15	12-29-66
L431	5F3	1.15	12-29-66
X013	3C1	----	11- 1-66
X009	4A2	3.20	12-21-66
XA07	4D3	4.95	12-21-66

Reprocessed Subassemblies Received from FCF

Subassembly No.	Date
C219	10-13-66
C226	11-21-66
C257	11-17-66
C262	11-22-66
C265	11-29-66
C276	10-14-66
C277	10-14-66
C278	10-20-66
C279	10-20-66
C280	10-22-66
C281	10-24-66
C282	10-24-66
C283	11-28-66
C284	10-25-66
C285	10-25-66
C286	11-18-66
C287	11-23-66
B325	12-13-66
B352	11-30-66
B354	12-27-66
B355	12- 2-66
B356	12- 3-66
B357	12-29-66
X017	11-11-66
X015	11-11-66
X018	12- 3-66
U1029	11-11-66
U1545	12- 3-66
U1118	12- 3-66
S605	10-14-66
L442	11- 8-66
L443	11- 9-66
L445	11-10-66
L446	11-11-66
L447	11-14-66
L448	11-16-66

* High Iron Content

III. Reactor Physics

A. Routine Measurements

Table IX gives the pertinent reactor variables for Runs No. 22 - 24.

TABLE IX

OPERATION PHYSICS DATA

Run No.	22	23	24
Excess Reactivity			
Initial (Ih)	295	227	295*
Final (Ih)	142	125	63*
Control Rod Banked			
Initial (in.)	11.4	12.0	11.25
Final (in.)	13.0	13.0	14.0
Controlling Rod			
Initial (in.)	7.2	5.7	6.5
Final (in.)	9.57	7.4	14.0
Overall Power Coefficient (Ih/MW)	1.53	1.45	1.41
Rod Drop Test	No	No	Yes
Integrated Power Increment (MWd)	1045	690	630

* The large difference between these two values is due to the fact that during the latter part of Run No. 24, Control Rod No. 1 was removed and replaced with the dummy stainless steel rod with a resultant loss of activity of $\sim$ 145 inhours.

B. Oscillator Studies

The new rotary oscillator was put into service during this quarter. The checkout showed that the limit of operation was from 8.7 cps maximum to .0015 cps minimum. Above 9 cps the rods vibrate rather badly and, hence, the operation is limited to <9 cps maximum. Between 5 and 8 cps a natural frequency of the rod occurs and, therefore, these frequencies are excluded from normal use.

A new method of data analysis was developed to increase the accuracy of the measurements as well as to decrease the time required for taking the transfer function as well as the time for analysis. This was accomplished by feeding the analog signals from the ion chamber and the sine and cosine potentiometer directly to an A to D converter and then to the IBM 1620 Computer. This technique allows one to compute the Fourier coefficients essentially on-line, using digital analysis techniques. The results are typed out immediately giving the amplitude and phase angle of the transfer function for each frequency. Using

this method, the time required to run the reactor transfer function from 8.7 cps to .007 cps is about 2 hours. Data taken below .007 cps requires another 2 hours because of the long sampling times involved.

Data were obtained during Run No. 24 under the following conditions:

1. Zero power (500 kW was used since the feedback effects are negligible, but the signal level is relatively large).

2. 30 kW, 100% flow, rods banked at 11.5 in.

3. 30 kW, 100% flow, rods banked at 14.0 in.

4. 20 kW, 52% flow, limited to frequency above 0.15 cps.

The oscillator was limited to the above operations because it was discovered that under conditions of power higher than 30 kW and corresponding lower flows that rubbing between the oscillator and thimble was occurring at low frequencies; therefore, operation was limited to those power flow conditions in which no rubbing occurred. The data obtained was very satisfactory and very encouraging with respect to the new analysis techniques. Figure 38 shows the data obtained for zero power and 30 kW, compared to the calculations at zero power. The results show very good agreement with theory in terms of amplitude. The phase data are not quite as good, but from an analysis of the oscillator rod design, it has been discovered that a 6° uncertainty in angular position is possible due to mechanical tolerances in the gripper mechanism.

A preliminary analysis of the data at 30 kW shows they have the same characteristics as the data taken at 30 kW during the initial approach to power with the smaller reference core.

C. Calculations

The calculational program for this quarter was directed toward obtaining results which would aid in examining the effects on power distribution when changes were made in the reactor core and blanket. A two-dimension x-y CANDID problem was run to compare with the foil results of Run No. 20. The results were not satisfactory.

IV. Experimental Irradiations

A. Experimental Subassembly Locations

Figures 39 through 41 show the locations of all the experimental subassemblies in the grid during reactor Runs No. 22, 23, and 24, as well as the locations of other special subassemblies, control and safety rods, and standard EBR-II driver subassemblies.

B. Experimental Subassembly Contents and Exposure Status

Descriptions of experimental capsules and exposures in the experimental subassemblies resident in the reactor during this report period are given in Table X.

V. Systems Maintenance, Improvements, and Tests

A. Electrical

The following preventive maintenance items were checked during this report period.

1. Three percentage differential relays for transformer No. 3. 13.8 primary.

   Three percentage differential relays for transformer No. 4. 13.8 primary.

   Three percentage differential relays for transformer No. 5. 13.8 kV primary.

   Three percentage differential relays for transformer No. 6. 13.8 kV primary.

2. ITE 600-Amp breakers for the primary pumps.

3. Overloads in auxiliary pump rectifier.

B. Mechanical

1. Turbine Inspection and Repair

As reported previously, the inspection and repair of the turbine was completed in August. The reassembly was completed before the start of Run No. 22. Initial operation of the turbine revealed a small steam leak in a joint which was subsequently repaired.

The emergency governor (overspeed trip) was not altered in any way during the overhaul; however, on startup, it caused the turbine to trip out before synchronous speed (3600 rpm) was reached. It was removed and inspected and found to be apparently in like-new condition in every respect. The adjustment was then changed and, through a trial and error process, a satisfactory tripping speed of 2950 rpm was obtained. Thereafter, the tripping speed was checked every time the machine was placed on, or taken off, the line. On one occasion, a further adjustment was necessary.

Successive tripping speeds have not been satisfactorily consistent, and the trip speed has been high.

After the completion of Run No. 24, the governor returned to the vendor's shop for bench testing and adjustment.

2. Secondary Sodium Pump M-G Set

A complete inspection of the secondary sodium M-G set generator was conducted, including the removal of the rotor, the replacement of the outboard journal bearing and the replacement of the coupling. Nothing was observed in the

V. System Maintenance, [illegible]

A. Electrical

The following [illegible] through the August period.

1. Three [illegible]

Three [illegible]

Three [illegible]

Three [illegible]

[illegible]

[illegible]

B. Mechanical

1. [illegible]

[illegible] was [illegible] in [illegible] which was [illegible]

[illegible] was [illegible] during the [illegible] before [illegible] and [illegible] was [illegible] speed of [illegible] that the [illegible] further [illegible]

[illegible] and the [illegible]

After the [illegible]

2. [illegible]

A complete inspection of the [illegible] was [illegible] [illegible], bearing and [illegible] mechanical operation of the unit, that would explain a chronic "thumping" noise during operation. The unit was reassembled and operation has revealed that the cause of the noise has not been eliminated. Further investigations will be conducted.

3. Secondary Storage Tank

A replacement immersion heater for the secondary storage tank was installed and has been put into service.

4. Small Rotating Plug Seal Gas

The installation of a hose reel for the small rotating plug seal gas hose was completed and has proven satisfactory.

5. Reactor Building Leak Rate Tests

Two electrical penetrations through the reactor building containment shell were modified to accept double flanges. This modification will allow representative leak rate testing on an annual basis without interrupting the electrical service.

The penetrations so modified were coaxial cable type No. 35, and a MI type, No. 23. The leak rates after completing the modifications were 0.220 ft^3/day and 0.012 ft^3/day, respectively.

Other penetrations tested during this report period and their leakage rates are as follows:

Penetration	Leakage Rate ft^3/day
Vacuum breaker valve penetration No. 26	0.84
8-in. manual pressure equalization valve	0.762
10-in. electrical penetrations (Nos. 9, 10, & 13)	less than 0.0003
6-in. electrical penetrations (Nos. 24, 25, 27, & 29)	less than 0.0003
8-in. electrical penetrations (Nos. 31 and 36)	less than 0.0003

All leakage rates were well below permissible values.

6. FERD Loop

The FERD Loop instrument cooling blower failed. It has been reconditioned and put back into service.

7. Motor Driven Feedwater Pump Control Valve VC-596

The motor driven feedwater control valve was sticking during operation. Disassembly of the valve operator revealed a spring stop had broken off and was interfering with the actuator movement. Repairs were made and the valve is now operating satisfactorily.

8. Primary Pump No. 1 Blower Motor

Due to excessive vibration of the blower and motor, a replacement motor was installed and the blower was rebalanced.

9. Turbine Initial Pressure Regulator Modification

A new isolation valve was installed in the high pressure steam system. This will enable isolation of the regulator during plant operation for repairs to the system.

10. Secondary System Plugging Loop

The bellows in the plugging valve in the plugging loop failed and a new bellows was installed.

11. Start-Up Feedwater Pump

Cylinders No. 2 and 3 on the start-up feedwater pump were repacked and the plunger alignment was checked.

12. Steam Bypass Valve VC-501B

The small steam bypass valve was disassembled for repairs. New bushings, steam and disc were required to repair the unit. This valve continues to be a high maintenance item.

13. Primary Sodium Purification System

Detailed design of a new primary sodium purification system was completed during this quarter. An engineering package, including drawings and written descriptions, procedures, etc., was prepared to cover installation of a new cold trap and piping system.

Replacement of the present cold trap necessitates removal of the pump and all piping from within the sodium purification cell. The new system is designed to allow future replacement of the cold trap through the purification cell access hatch without disturbing the remainder of the system. All piping connections to the new cold trap will be accomplished with remotely operable couplings. This will allow disconnect and removal of the cold trap without entry into the cell.

At the end of this report period, two identical cold traps, one a spare, were nearing completion by the fabricator. All other materials were either on hand or on order. Prefabrication of some system components has begun.

14. Mark II Oscillator Rod Installation

During this report period, the installation of the Mark II Oscillator Rod was completed. Initial attempts to operate the oscillator with the reactor at power showed that a mis-alignment occurred when the control rod lifting platform was put in the "reactor operate" position. It was necessary to re-align the upper drive assembly with the reactor operating to eliminate the

mis-alignment. Further operation of the oscillator has shown that there still is a binding problem associated with oscillator rotation, but it is apparently caused by temperature-induced distortion, or bowing, of the oscillator rod itself in the control rod thimble; it is also possible that a change in alignment of the control rod thimble in relation to the reactor vessel cover as reactor power is increased has the the same effect. The binding occurs only when the reactor ΔT is greater than 90-100°F and then only when the rotational speed is less than 3 cps. At higher rotational speeds or at a lower reactor ΔT, operation has been very satisfactory. The upper speed limit of the oscillator in the reactor has been set at 9 cps, since vibration is encountered above this speed. We are presently looking at possible modifications to the oscillator rod itself to achieve satisfactory operation at any rotational speed below 9 cps with a reactor ΔT less than 100°F.

15. Fuel Unloading Machine (FUM) Operations

The FUM gripper has required cleaning after relatively few transfers for several months. Several tests have been performed in an attempt to locate the problem but none have been successful. Recently, the entire argon system was checked for leaks and several possible leaks were repaired, improving operation somewhat. The last adjustment was to the opening and closing cams on the gripper jaws to relieve some potential tight spots around the jaws. Also, the tension on the sensing rod chain was reduced by one-half. This maintenance has apparently increased the number of cycles between cleaning operations. Design of a new and simpler FUM gripper is underway and attempts to get better operation from the present system continues. A detailed study of the argon system has also been started to determine areas where modifications may be required.

C. Instrumentation and Control

1. Mark II Oscillator

The wiring for control of the oscillator drive and its interconnection with fuel handling has been completed. Operational checkouts were performed satisfactorily. Cabling has been installed between the power plant and the computer lab for direct handling of the data as generated. Because of the long transmission lines between the power plant and computer lab, amplifiers were installed in the power plant to maintain signal level at the computer lab.

As the oscillator data is generated, it is fed in parallel to the tape recorder and the analog-to-digital converter in the computer lab. The magnetic tape record is used for historical record and for checkpoint re-runs on the computer. The A-D converter permits on-line analysis of the various frequencies. Although a limited amount of data has been processed, the results of the data processed thus far has indicated the data system is acceptable.

2. Rod Drop Test

As a result of a previous rod drop test, the magnetic clutch on rod No. 12 was removed and replaced with a spare. The overall drop time was reduced by 30 to 50 msec, bringing the drop time in line with the remaining rods.

3. Constant Power Supply

A specification has been prepared and sent out for bids for transfer switches required to parallel the two constant power supplies with site power. To date, one bid has been received but has not been accepted. The bidding date was extended. All bids are now due 1-21-67.

4. Differential Pressure Gauges for the FUM Argon Cooling System

Differential pressure gauges have been installed across the vapor traps, heat exchangers, and pertinent components to monitor for plugging.

5. Fuel Handling System

A limit switch has been installed at the 25 ft level of the Fuel Unloading Machine (FUM) gripper vertical travel. By stopping at this level instead of at 21 ft, the gripper will still be in the primary tank sodium and the requirement that the gripper be arrested to drain free of sodium can be eliminated for transfers from the basket to the gripper. Gripper maintenance has been reduced, and twice has been saved, as the result of this modification.

6. Penetration Leak Test Fixture

A coaxial cable connector terminal plate has been installed to permit leak testing the coaxial cable penetrations in the containment vessel. The two terminal plates were interconnected in the penetration using short lengths of cable made up to match the connectors.

7. Primary Sodium Level

The primary tank bulk sodium level instrumentation has been the cause of approximately 1/3 of the reactor scrams experienced during the report period. The cause of the mal-function (low level trips) cannot be definitely isolated but appears to be associated with a change in temperature and more specifically with a rate-of-change of temperature that occurs between 15 to 30 MW thermal reactor power. Testing to determine the deficiency is in progress.

To provide level indication in case of complete failure of the existing level instrumentation, induction coils have been manufactured and matched to solid state trip amplifiers. Two coils will be used, one for high and the second for low level trip. Both coils will be submerged below the sodium level in an existing pipe in the level probe nozzle. Because the two coils will be in opposing arms of a Wheatstone bridge, temperature compensation will be automatic within the bridge.

Design of a new type of instrument has been completed. This device uses a stationary weight and measures the change in weight, which is a function of sodium level. Drafting work has begun.

8. Solid State Source Range Channel

The source range channel has been received from the equipment manufacturer. Shop testing has been limited to date, but will be accelerated

to complete the device in time for installation in the reactor protective system prior to reactor Run No. 26.

9. Process Constant Power Supply

During the course of routine maintenance, a groove was detected in two of the four slip rings on the 20 KW AC generator. The slip rings were removed and a cut was taken on the ring to true it up. A cut of approximately 0.004 in. was taken on one ring and 0.002 in. on the second. New brushes were fitted to the rings and the unit was restored to service.

10. FERD Loop Electronics

During reactor Run No. 24, an increase of approximately 10% in counting rate was detected in counting channel "B". Investigation of the equipment indicates that the change in counting rate was caused by a leaking filter capacitor in the high voltage supply to the detectors. The high voltage power supply was a new power supply recently installed, but components had not been aged. The capacitor was replaced with a new component and will be monitored for continued operation.

TABLE X
SUMMARY OF CAPSULE IRRADIATIONS IN EBR-II
12-31-66

IRRADIATED TO 12-31-66

CAPSULES, FUEL - 172
CAPSULES, MTLS. - 90 MK-A
7 MK-B-7
TOTAL 269
NO. OF SUBASSY'S. 18

SUB ASSEMBLY	GRID LOCATION	EXPERI-MENTER(S)	GOAL EXPOSURE MWd	ACTUAL FINAL EXPOSURE MWd	STATUS AS OF 12-31-66 MWd	DATE INSTALLED	DATE REMOVED	FUEL CAPSULES: FUEL	FUEL CAPSULES: NO. OF CAPS & DESIGNATION	FUEL CAPSULES: POWER GENERATION KW/FT MAX	FUEL CAPSULES: POWER GENERATION KW/FT MIN	FUEL CAPSULES: MID-PLANE BURNUP RATES a/o /MWd X 10^4 MAX	FUEL CAPSULES: MID-PLANE BURNUP RATES a/o /MWd X 10^4 MIN	FUEL CAPSULES: STATUS AS OF 12-31-66 %BU(MAX)	MATERIAL CAPSULES: NO. OF CAPS & DESIGNATION	MATERIAL CAPSULES: MATERIAL	TYPE OF SAMPLE: BURST TEST	TYPE OF SAMPLE: TENSILE	TYPE OF SAMPLE: CREEP RUPTURE	STATUS AS OF 12-31-66 NVT X 10^{-22} TOTAL FLUX
XA01	6D2	ANL-MET	14,000	3,940*	3940	5- 6-65	3-24-66	U-Pu-Fz	19- C93 C97 C98 C99 C100 C101 CA01 CB02 CB03 CB04 CD01 CD02 CG02 CG03 CJ01 CM01 LA02 PA01 PB02	2.7	2.0	1.23	.91	0.48						
XG01	4F2	GE	700	381*	381	5- 6-65	5-23-65	UO_2-20PuO_2	6- FIA FIB FIC FID FIE FIF	16	14	5.78	5.08	0.22						
		GE													4- PIA	347	X	X		0.14
															PIB	347	X	X		
															MT1	HAST X INCO-625 I-800		X		
															MT2	HAST-X INCO-625 I-800		X		
XG02	7A1	GE	13,600		9744	7-16-65		UO_2-PuO_2	1- FOE	5.3		1.99		1.9						
XG03	7D1	GE	19,450		9744	7-16-65		UO_2-PuO_2	2- FOA FOC	5.3	4.6	1.99	1.83	1.9						

TABLE X (Cont.)

SUB ASSEMBLY	GRID LOCATION	EXPERI-MENTER(S)	GOAL EXPOSURE MWd	ACTUAL FINAL EXPOSURE MWd	STATUS AS OF 12-31-66 MWd	DATE INSTALLED	DATE REMOVED	FUEL CAPSULES: FUEL	NO. OF CAPS & DESIGNATION	POWER GENERATION KW/FT MAX	MIN	MID-PLANE BURNUP RATES o/o /MWd X 10^4 MAX	MIN	STATUS AS OF 12-31-66 %BU(MAX)	MATERIAL CAPSULES: NO. OF CAPS & DESIGNATION	MATERIAL	TYPE OF SAMPLE: BURST TEST	TENSILE	CREEP RUPTURE	STATUS AS OF 12-31-66 NVT X 10^{-22} TOTAL FLUX
XG04	7B1	GE	39,000		9744	7-16-65		UO_2-PuO_2	2- FOB FOD	5.3	4.6	1.99	1.83	1.9						
XG05	4C2	GE	10,300		9317	9- 3-65		UO_2-PuO_2	9- F2C F2D F2G F2H F2O F2R F2T F2V F2X	14.6	12.8	5.78	5.08	5.4	5- L2A L2C L2E L2G L2I	I-800 316 L 347 304 321	X X X X X	X X X X X		3.4
		ANL			9317			UC-PuC	3- HMV-5 NMV-11 SMV-2	18.3	17.8	5.38	5.20	5.0						
		ANL			9317			U-15Pu-10Zr	2- NC-17 ND-24	8.1	8.0	4.97	4.89	4.6						
XG06	4E2	GE	20.600		9317	9- 3-65		UO_2-PuO_2	12- F2A F2B F2E F2F F2N F2P F2Q F2S F2U F2W F2Y F2Z	14.6	12.8	5.78	5.08	5.4	5- L-2'-K L-2'-M L-2'-O L-2'-P L-2'-Q	I-800 316 L 347 321 304	X X X X X	X X X X X		3.4
		ANL			9317			U-15Pu-10Zr	2- NC-23 ND-23	8.7	8.1	5.32	4.97	5.0						

TABLE X (Cont.)

SUB ASSEMBLY	GRID LOCATION	EXPERI-MENTER(S)	GOAL EXPOSURE MWd	ACTUAL FINAL EXPOSURE MWd	STATUS AS OF 12-31-66 MWd	DATE INSTALLED	DATE REMOVED	FUEL CAPSULES: FUEL	FUEL CAPSULES: NO. OF CAPS & DESIGNATION	FUEL CAPSULES: POWER GENERATION KW/FT MAX	FUEL CAPSULES: POWER GENERATION KW/FT MIN	FUEL CAPSULES: MID-PLANE BURNUP RATES a/o /MWd x 10^4 MAX	FUEL CAPSULES: MID-PLANE BURNUP RATES a/o /MWd x 10^4 MIN	FUEL CAPSULES: STATUS AS OF 12-31-66 %BU(MAX)	MATERIAL CAPSULES: NO OF CAPS & DESIGNATION	MATERIAL CAPSULES: MATERIAL	MATERIAL CAPSULES: TYPE OF SAMPLE: BURST TEST	MATERIAL CAPSULES: TYPE OF SAMPLE: TENSILE	MATERIAL CAPSULES: TYPE OF SAMPLE: CREEP RUPTURE	MATERIAL CAPSULES: STATUS AS OF 12-31-66 NVT X 10^{-22} TOTAL FLUX
XA07	4D3	ANL	18,600	7950	7950	10-27-65	12- 5- 66	U-15Pu-9Zr	16- ND-25 ND-26 ND-27 ND-28 ND-29 ND-30 ND-31 ND-32 ND-33 ND-34 ND-35 ND-37 ND-39 ND-41 ND-43 ND-44	8.9	7.8	5.48	4.81	4.35	3- As-9 As-10 As-11	 V-20Ti HAST-X 304			 X X X	3.0
XA08	4F2	ANL	19,800		7495	12-13-65		(Pu-U)C	8- HMV-1 HMV-4 HWMP-1 HWMV-1 NMP-2 NMV-4 NMV-7 NMV-12	25.0	16.2	5.83	5.10	4.4	9- As-1 As-2 As-3 As-4 As-5 As-6 As-7 As-8 As-12	 V-20Ti V-20Ti HAST-X HAST-X 304 V-20Ti HAST-X 304 V-20Ti	 X X X X X		 X X X X	2.8
		GE			7495										2- MT-3 MT-4	 I-800 I-800		 X X		2.8
X009	4A2	UNC	5,130	5355	5355	3-24-66	11-14-66	PuC-UC	3- UNC-78 UNC-79 UNC-80	26.5	18.5	5.74	5.56	3.07						
		ANL			5355			PuC-UC	3- SMP-1 SMV-1 VMV-1	25.5	17.1	5.83	5.10	3.12	3- As-14 As-15 As-27	 V-20Ti V-20Ti 304		 X X X		2.0
		ANL			5355			UO_2-PuO_2	2- SOV-5 SOV-6	14.0	13.3	5.33	5.16	2.86						
		PNWL (ANL)			5355			PuO_2-S/S	2- SP-13 SP-14	9.6	6.1	6.19	6.19	3.21	4- A-1 A-2 A-5 A-6	304		X X X X	X X X X	2.0

TABLE X (Cont.)

SUB ASSEMBLY	GRID LOCATION	EXPERIMENTER (S)	GOAL EXPOSURE MWd	ACTUAL FINAL EXPOSURE MWd	STATUS AS OF 12-31-66 MWd	DATE INSTALLED	DATE REMOVED	FUEL CAPSULES: FUEL	FUEL CAPSULES: NO. OF CAPS & DESIGNATION	POWER GENERATION KW/FT MAX	POWER GENERATION KW/FT MIN	MID-PLANE BURNUP RATES a/o /MWd X 10^4 MAX	MID-PLANE BURNUP RATES a/o /MWd X 10^4 MIN	STATUS AS OF 12-31-66 %BU(MAX)	MATERIAL CAPSULES: NO. OF CAPS & DESIGNATION	MATERIAL	TYPE OF SAMPLE: BURST TEST	TYPE OF SAMPLE: TENSILE	TYPE OF SAMPLE: CREEP RUPTURE	STATUS AS OF 12-31-66 NVT X 10^{-22} TOTAL FLUX
X009 (CONT.)		GE													2-					2.0
															L-4-C	316	X	X		
															L-4-D	316	X			
X010	7F3	GE	19,600		6675	3-24-66		UO_2-PuO_2	4-	8.1	7.3	3.00	2.77	1.9						
									FOJ											
									FOK											
									FOL											
									FOM											
		ANL			6675										11-					1.1
															As-16	V-20Ti		X		
															As-17	V-20Ti		X		
															As-18	V-20Ti		X		
															As-19	HAST-X			X	
															As-20	V-20Ti, 304 HAST-X			X	
															As-21	V-20Ti	X			
															As-22	304				
															As-23	304				
															As-24	304				
															As-25	304				
															As-26	304				
		PNWL			6675										4-					1.1
															A-3	304		X	X	
															A-4	304		X	X	
															A-7	304		X	X	
															A-8	304		X	X	
X011	2F1	ANL	8,300		5104	5- 9-66		UO_2-$20PuO_2$	7-	19.2	16.2	6.11	5.81	3.1						
									HOV-4											
									HOV-10											
									HOV-15											
									SOV-1											
									SOV-3											
									SOV-7											
									TVOV-1											

TABLE X (Cont.)

SUB ASSEMBLY	GRID LOCATION	EXPERI-MENTER(S)	GOAL EXPOSURE MWd	ACTUAL FINAL EXPOSURE MWd	STATUS AS OF 12-31-66 MWd	DATE INSTALLED	DATE REMOVED	FUEL CAPSULES: FUEL	FUEL CAPSULES: NO. OF CAPS & DESIGNATION	POWER GENERATION KW/FT MAX	POWER GENERATION KW/FT MIN	MID-PLANE BURNUP RATES a/o / MWd X 10^4 MAX	MID-PLANE BURNUP RATES a/o / MWd X 10^4 MIN	STATUS AS OF 12-31-66 °/oBU(MAX)	MATERIAL CAPSULES: NO. OF CAPS & DESIGNATION	MATERIAL	TYPE OF SAMPLE: BURST TEST	TYPE OF SAMPLE: TENSILE	TYPE OF SAMPLE: CREEP RUPTURE	STATUS AS OF 12-31-66 NVT X 10^{-22} TOTAL FLUX
X011 (CONT.)		GE			5104			UO_2-20PuO_2	9- F4A F4D F4E F4F F4G F4H F4J F4K F4L	16.9	15.5	6.11	5.81	3.1						
		PNWL			5104			PuO_2-S/S	2- 5P-9 5P-12	10.9	7.1	7.10	7.04	3.6						
		PNWL			5104			UO_2-S/S	1- 5U-14	5.6	5.6	5.78		3.0						
X012	4B2	NuMEC	20.600		2975	8-10-66		UO_2-20PuO_2	19- C-1 C-2 C-3 C-4 C-6 C-7 C-8 C-9 C-10 C-11 C-12 C-13 C-14 C-15 C-16 C-17 C-18 C-19 D-5	14.6	12.7	5.74	5.08	1.7						
X013	3C1	ANL	1,200	1,3C9	1309	7-17-66	9- 7-66								18- As-34	HAST-X	X	X		0.57
															As-35	INCO-625	X			
																V-20Ti		X		
															As-36	INCO-625	X			
																V-20Ti		X		

TABLE X (Cont.)

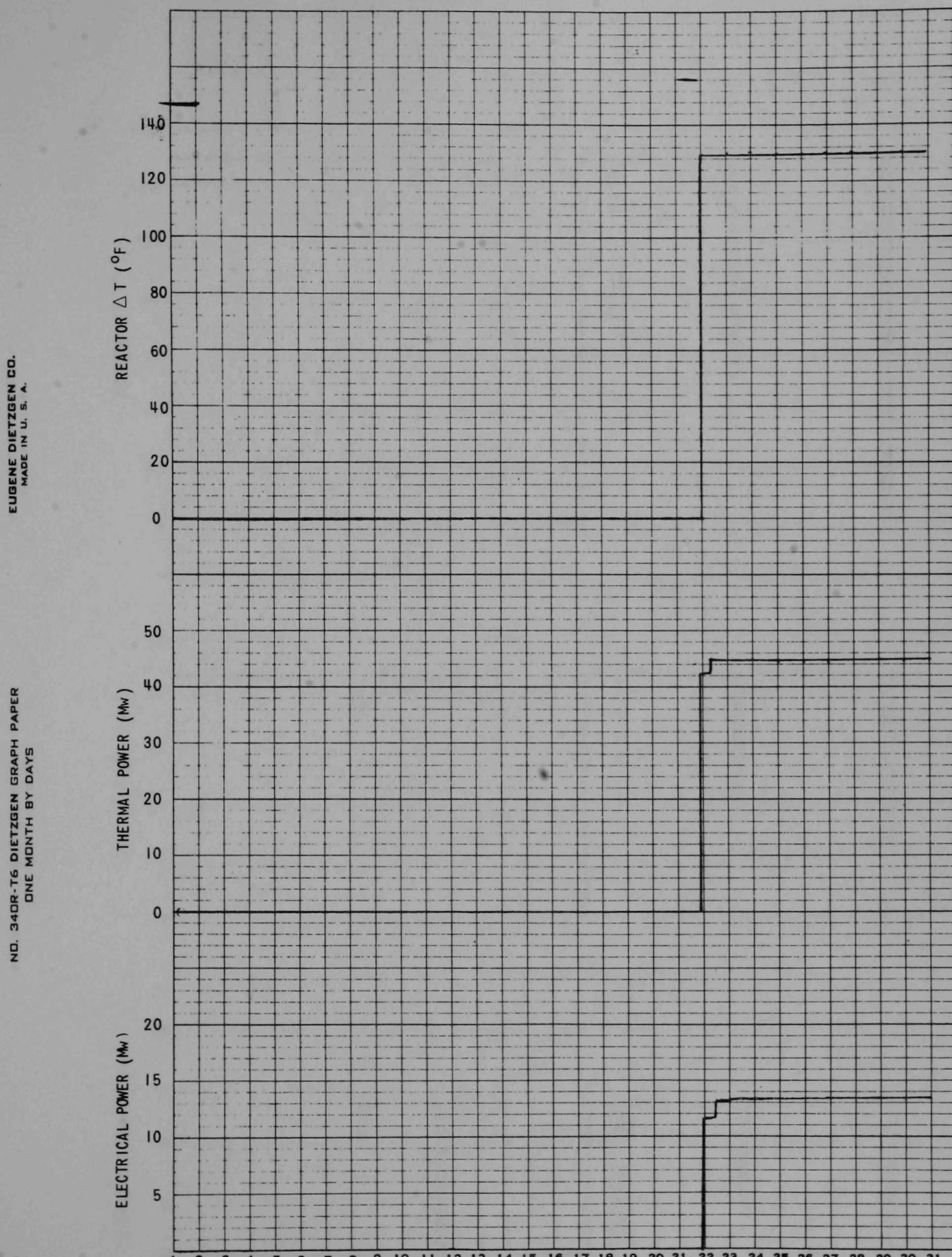
SUB ASSEMBLY	GRID LOCATION	EXPERI-MENTER(S)	GOAL EXPOSURE MWd	ACTUAL FINAL EXPOSURE MWd	STATUS AS OF 12-31-66 MWd	DATE INSTALLED	DATE REMOVED	FUEL CAPSULES: FUEL	FUEL CAPSULES: NO. OF CAPS & DESIGNATION	FUEL CAPSULES: POWER GENERATION KW/FT MAX	FUEL CAPSULES: POWER GENERATION KW/FT MIN	FUEL CAPSULES: MID-PLANE BURNUP RATES a/o / MWd X 10^4 MAX	FUEL CAPSULES: MID-PLANE BURNUP RATES a/o / MWd X 10^4 MIN	FUEL CAPSULES: STATUS AS OF 12-31-66 %BU(MAX)	MATERIAL CAPSULES: NO. OF CAPS & DESIGNATION	MATERIAL CAPSULES: MATERIAL	TYPE OF SAMPLE: BURST TEST	TYPE OF SAMPLE: TENSILE	TYPE OF SAMPLE: CREEP RUPTURE	STATUS AS OF 12-31-66 NVT X 10^-22 TOTAL FLUX
X013 (CONT)															As-37	HAST-X	X	X		
															As-38	V-15Ti				
																7.5 CR	X			
																V-20Ti		X		
															As-39	V-15Ti				
																7.5 CR	X			
																V-20Ti		X		
															As-40	V-15Ti				
																7.5 CR	X			
																V-20Ti		X		
															As-41	V-15Ti				
																7.5 CR	X			
																V-20Ti		X		
															As-42	V-15Ti				
																7.5 CR	X	X		
															As-43	V-15Ti				
																7.5 CR	X	X		
															As-44	V-15Ti				
																7.5 CR	X	X		
															As-45	INCO-625	X			
																V-15Ti				
																7.5 CR		X		
															As-46	HAST-X	X	X		
															As-47	304	X	X		
															As-48	304	X	X		
															As-49	304	X	X		
															As-54	V-15Ti				
																7.5 CR	X	X		
															As-55	INCO-625	X			
																V-15Ti				
																7.5 CR		X		
		PNWL			1309										1- BG-1	GRAPHITE				.57
X014	2D1	PNWL	**		3674	7-17-66									5-					
															A-9	304		X		1.7
															A-10	348		X		
															A-11	348		X		
															A-12	304		X		
															A-13	304 & 348				

TABLE X (Cont.)

SUB ASSEMBLY	GRID LOCATION	EXPERI-MENTER(S)	GOAL EXPOSURE MWd	ACTUAL FINAL EXPOSURE MWd	STATUS AS OF 12-31-66 MWd	DATE INSTALLED	DATE-REMOVED	FUEL CAPSULES: FUEL	FUEL CAPSULES: NO. OF CAPS & DESIGNATION	FUEL CAPSULES: POWER GENERATION KW/FT MAX	FUEL CAPSULES: POWER GENERATION KW/FT MIN	FUEL CAPSULES: MID-PLANE BURNUP RATES a/o /MWd X 10^4 MAX	FUEL CAPSULES: MID-PLANE BURNUP RATES a/o /MWd X 10^4 MIN	FUEL CAPSULES: STATUS AS OF 12-31-66 %BU(MAX)	MATERIAL CAPSULES: NO. OF CAPS & DESIGNATION	MATERIAL CAPSULES: MATERIAL	TYPE OF SAMPLE: BURST TEST	TYPE OF SAMPLE: TENSILE	TYPE OF SAMPLE: CREEP RUPTURE	STATUS AS OF 12-31-66 NVT X 10^{-22} TOTAL FLUX
X014 (CONT)		GE			3674										5-					1.7
															L4A	I-800	X	X		
															L4B	I-800	X	X		
															L4E	347	X	X		
															L4F	304	X	X		
															L4G	321	X	X		
		NRL			3674										5-					
															NRL-1	I-800		X		1.7
																HAST-X		X		
																304, 316		X		
															NRL-2	I-800		X		
																316		X		
															NRL-3	I-800				
																304		X		
																316		X		
															NRL-4	I-800				
																304		X		
																316		X		
															NRL-5	INCO-625		X		
																HAST-X				
																316		X		
		PNWL			3674										2-					
															BG-2	GRAPHITE				1.7
															BG-3	GRAPHITE				
		GE			3674										2-					
															MT-5	I-800	X	X		1.7
															MT-6	I-800	X	X		1.7
X015	4A2	NUMEC	11,000		1320	11-15-66		UO_2-$20PuO_2$	11-	14.5	13.2	5.70	5.25	0.8						
									B-1											
									B-2											
									B-3											
									B-4											
									B-5											
									B-6											
									B-7											
									B-8											
									B-9											
									B-10											
									B-11											
		GE			1320			UO_2-$20PuO_2$	2-	13.2	13.2	5.25	5.25	0.7						
									F7C											
									F7D											

TABLE X (Cont.)

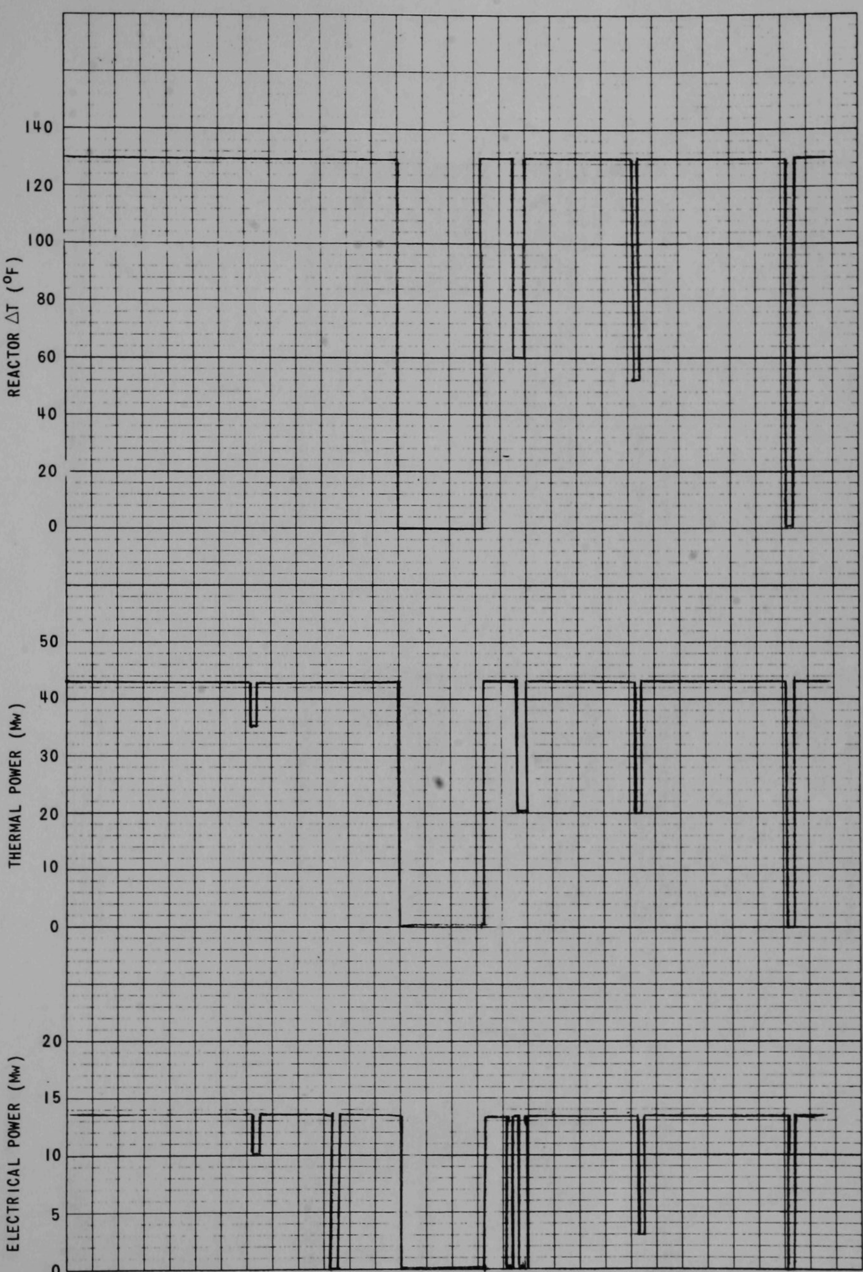
SUB ASSEMBLY	GRID LOCATION	EXPERIMENTER(S)	GOAL EXPOSURE MWd	ACTUAL FINAL EXPOSURE MWd	STATUS AS OF 12-31-66 MWd	DATE INSTALLED	DATE REMOVED	FUEL CAPSULES: FUEL	FUEL CAPSULES: NO OF CAPS & DESIGNATION	FUEL CAPSULES: POWER GENERATION KW/FT MAX	FUEL CAPSULES: POWER GENERATION KW/FT MIN	FUEL CAPSULES: MID-PLANE BURNUP RATES a/o / MWd $\times 10^4$ MAX	FUEL CAPSULES: MID-PLANE BURNUP RATES a/o / MWd $\times 10^4$ MIN	FUEL CAPSULES: STATUS AS OF 12-31-66 %BU(MAX)	MATERIAL CAPSULES: NO OF CAPS & DESIGNATION	MATERIAL CAPSULES: MATERIAL	MATERIAL CAPSULES: TYPE OF SAMPLE: BURST TEST	MATERIAL CAPSULES: TYPE OF SAMPLE: TENSILE	MATERIAL CAPSULES: TYPE OF SAMPLE: CREEP RUPTURE	MATERIAL CAPSULES: STATUS AS OF 12-31-66 NVT $\times 10^{-22}$ TOTAL FLUX
X015 (CONT)		ANL			1320			$(U_{.8}Pu_{.2})C$	4- NMV-3 TVMV-1 HMV-2 NMP-1	25.0	17.6	5.74	3.87	0.8						
		ANL			1320			MK-IA (METAL)	2- BF02 BF03	7.2	7.2	2.98	2.98	0.4						
X017	4C3	NuMEC	6.500		1320	11-15-66		UO_2-$20PuO_2$	11- A1 A2 A3 A4 A5 A6 A7 A8 A9 A10 A11	14.5	12.7	5.70	5.08	0.8						
		UNC			1320			$(U_{.8}Pu_{.2})C$	3- 87 89 90	26.8	25.2	5.83	5.46	0.8						
		ANL			1320			MK-IA METAL	5- BF04 BF05 BF08 BF09 BF11	7.9	7.7	3.24	3.18	0.4						
X018	2B1	GE	21.300		630	12-6-66									3- a b c	 1800,316 304,316 304,321 347	 X X X	 X X X		0.30
		ANL			630										3- As56 As57 *As58	 V20Ti,V15 Ti-7, 5Cr HAST-X 304 V20Ti,V15 Ti-7.5 Cr	 X X X	 X X X	 X X X	0.30
		PNWL			630										1- 7-1	 304, 316 321, 348		 X X		



REACTOR ΔT, THERMAL POWER AND ELECTRIC POWER

MONTH OCTOBER 19 66

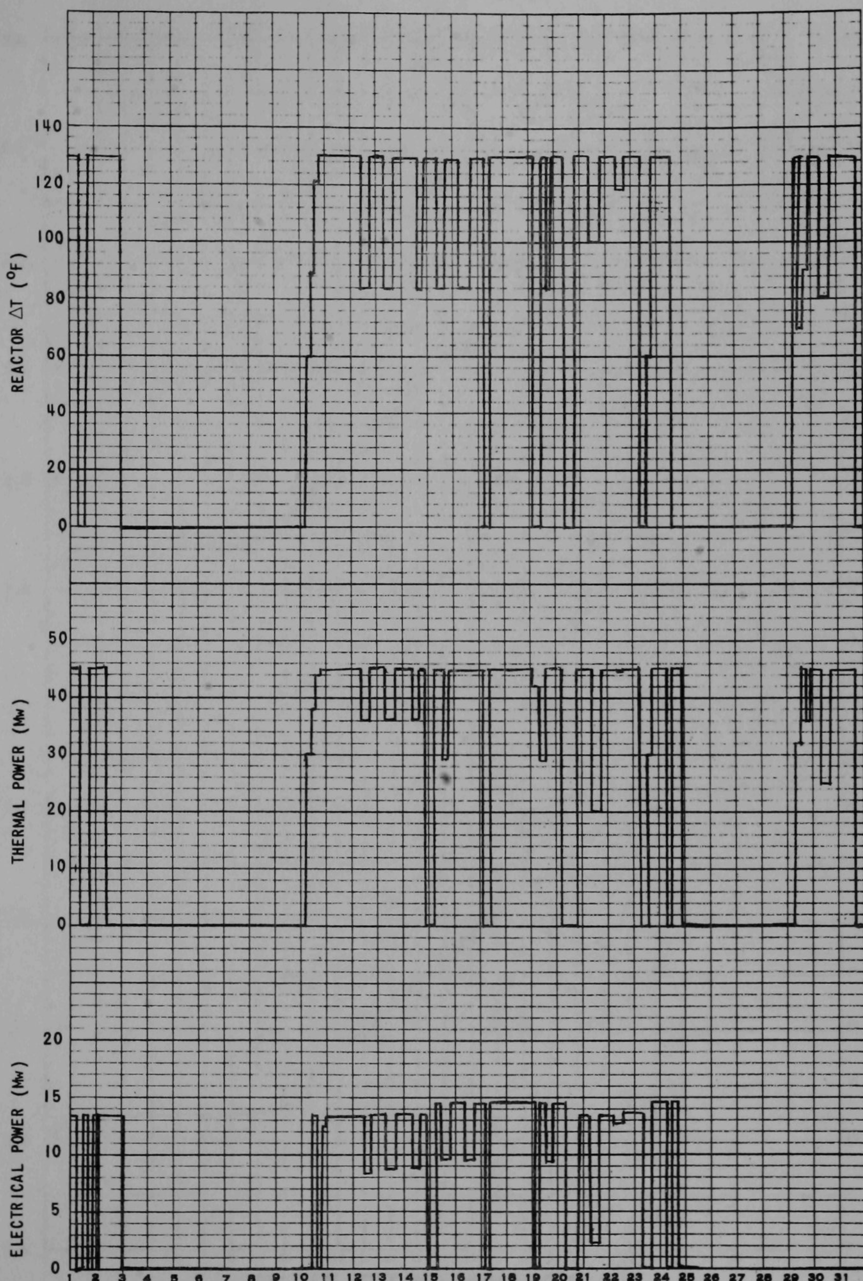
FIG. I



REACTOR ΔT, THERMAL POWER, AND ELECTRICAL POWER

MONTH NOVEMBER 19 66

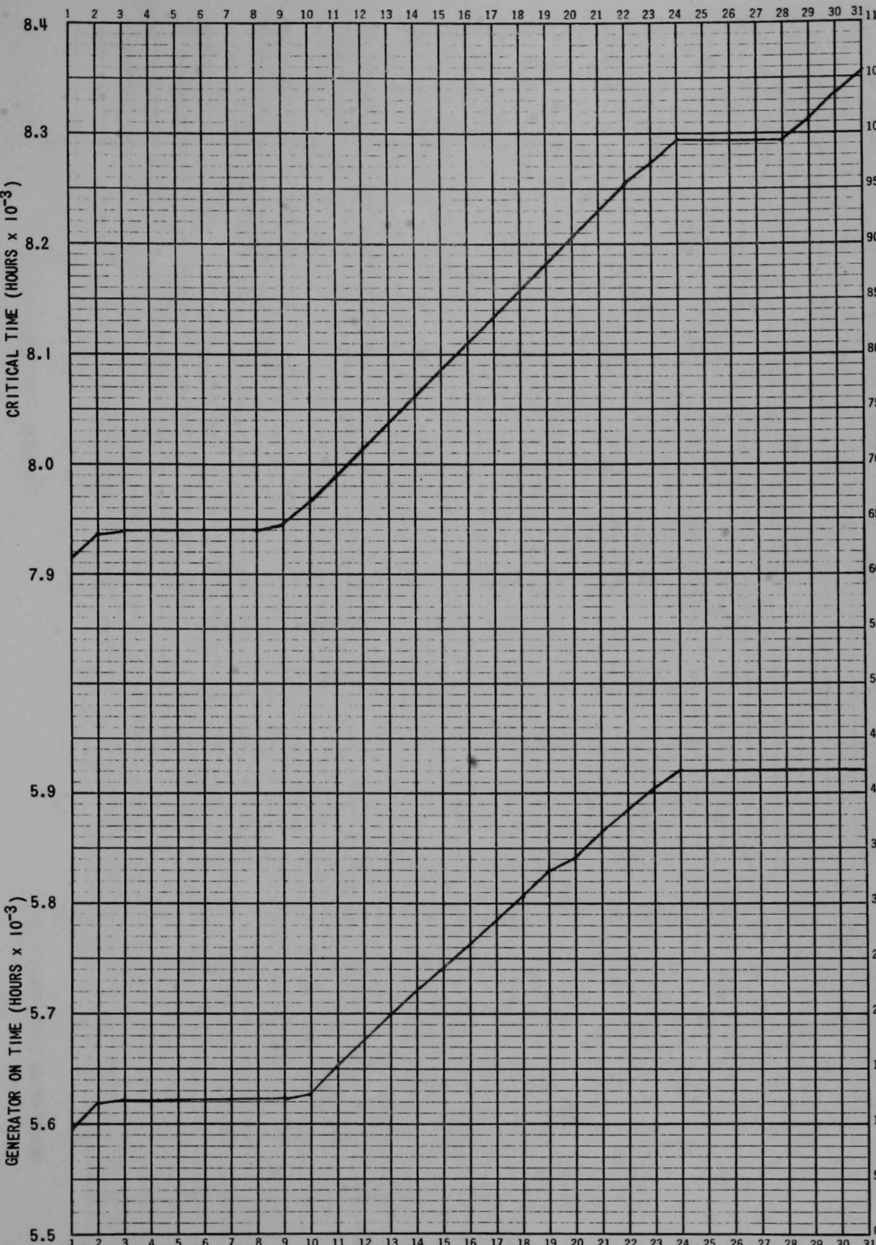
FIG. 2



REACTOR ΔT, THERMAL POWER AND ELECTRICAL POWER

MONTH DECEMBER 19 66

FIG. 3



CRITICAL TIME AND GENERATOR ON TIME

Month DECEMBER 19 66

FIG. 4

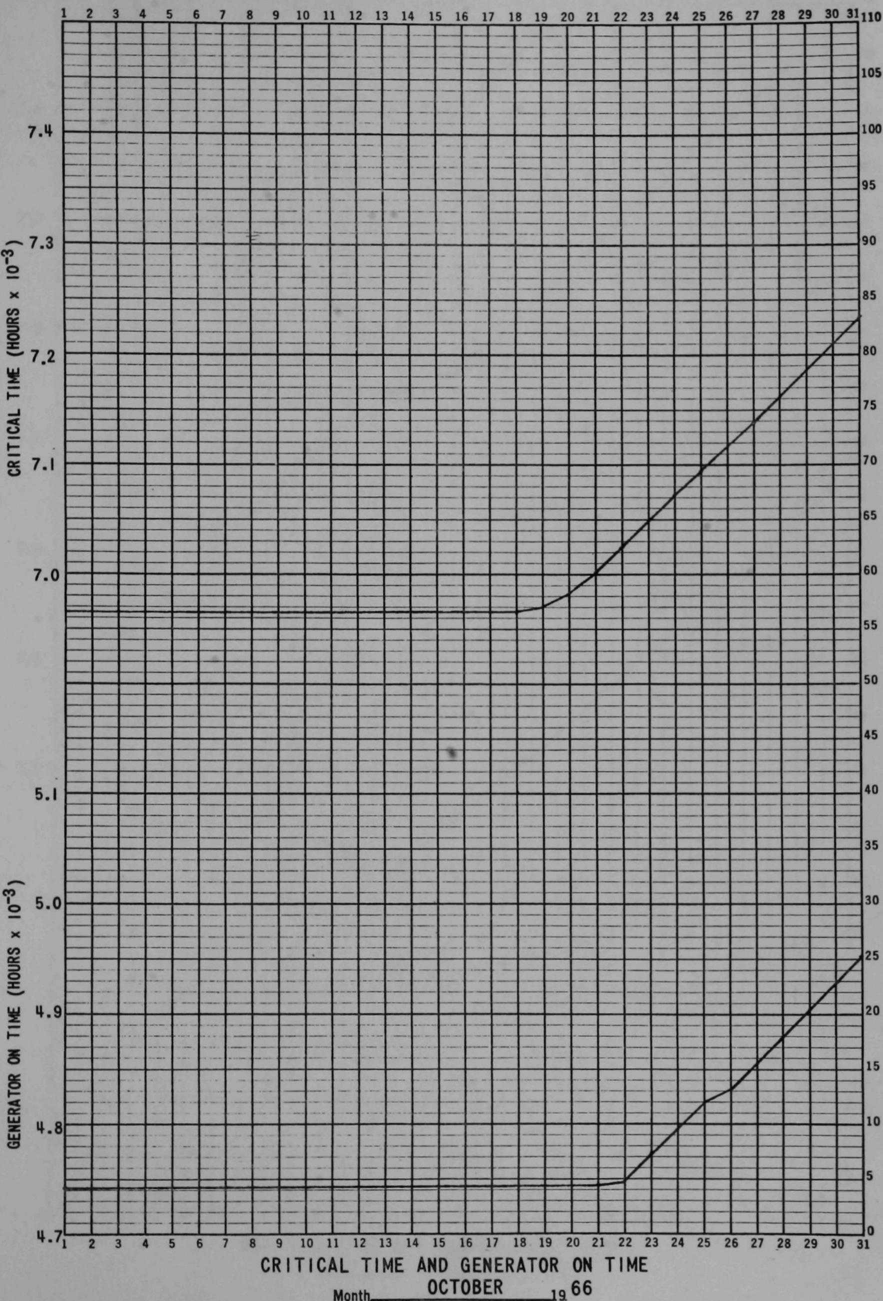
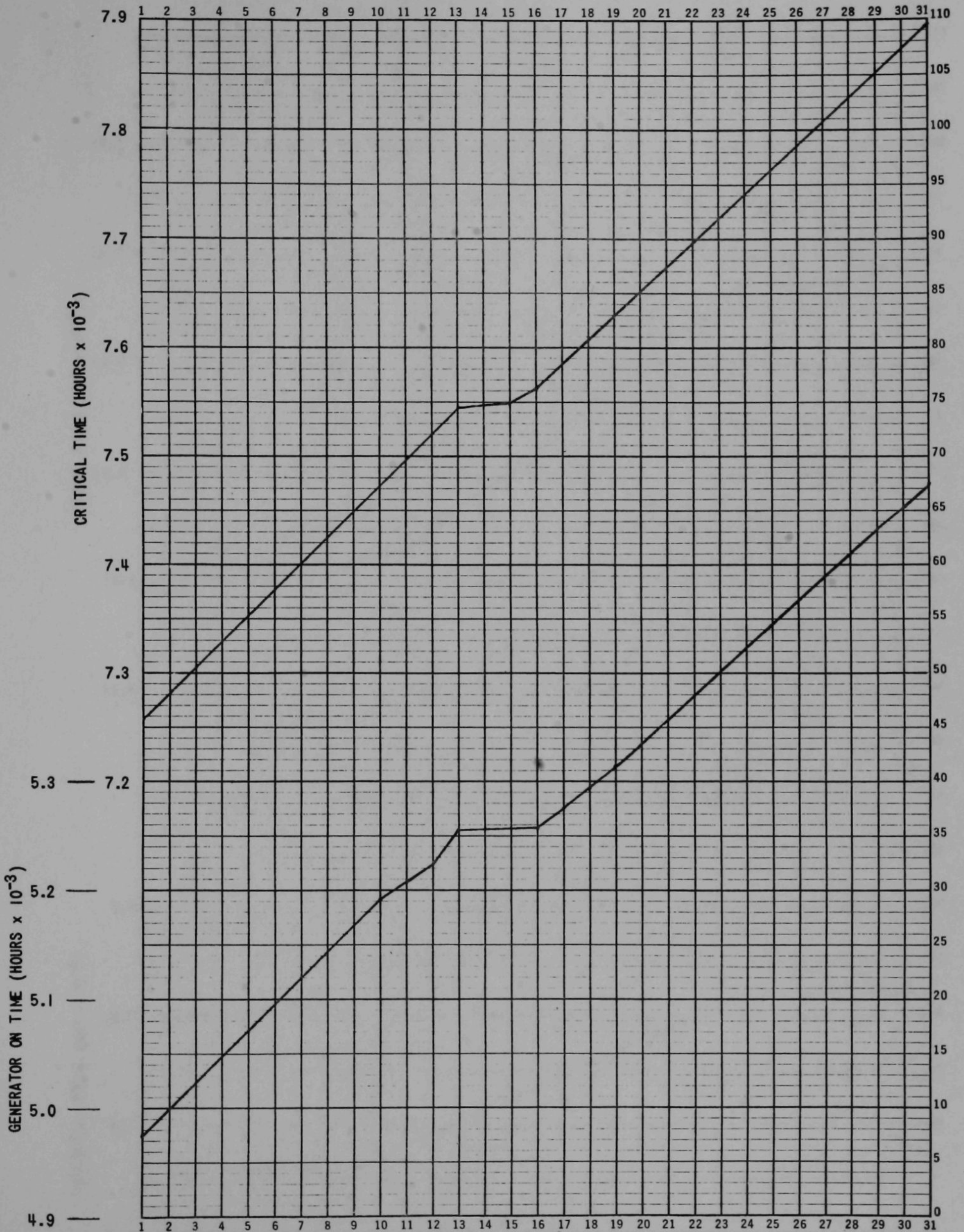

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
CRITICAL TIME (HOURS x 10^{-3})
GENERATOR ON TIME (HOURS x 10^{-3})
7.4
7.3
7.2
7.1
7.0
5.1
5.0
4.9
4.8
4.7
110
105
100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
CRITICAL TIME AND GENERATOR ON TIME
Month OCTOBER 19 66

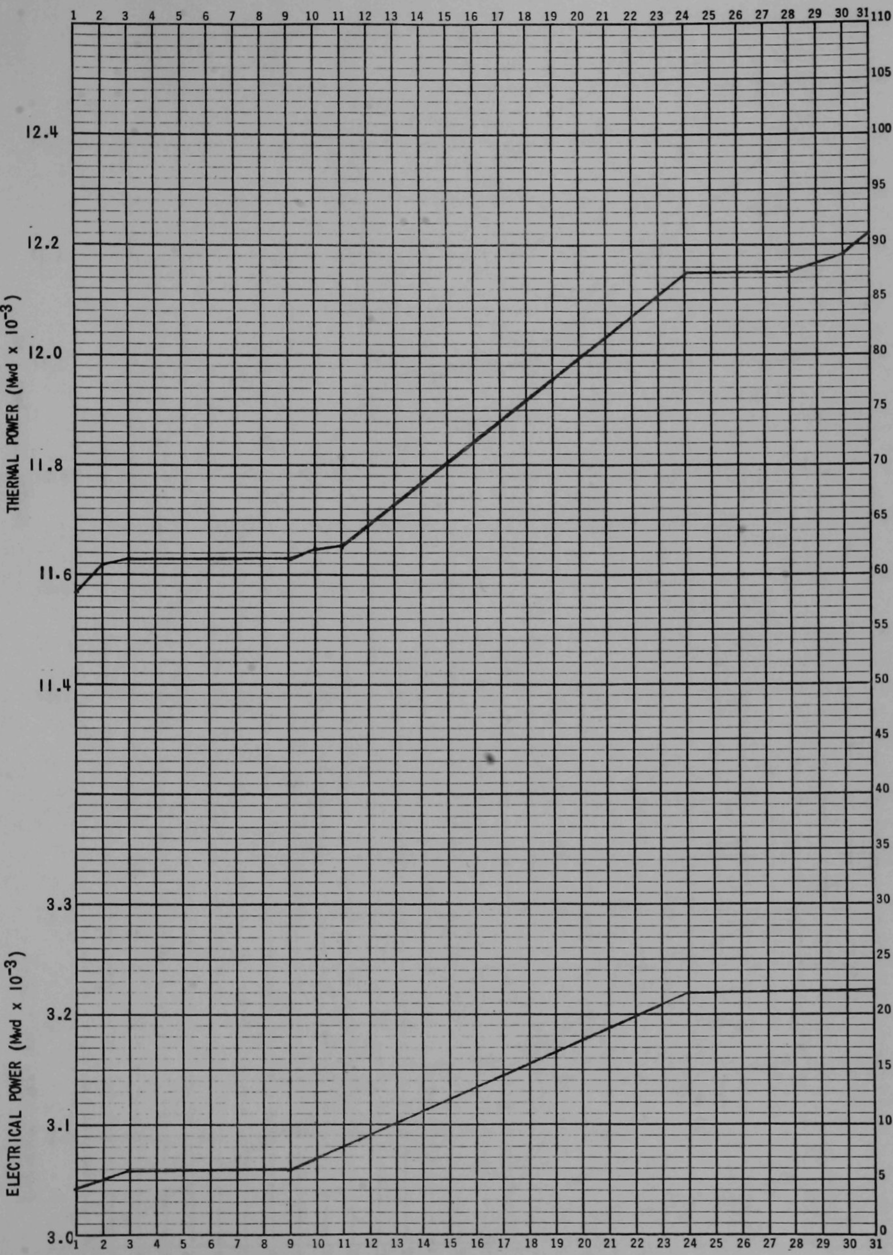
FIG. 5



CRITICAL TIME AND GENERATOR ON TIME

Month NOVEMBER 1966

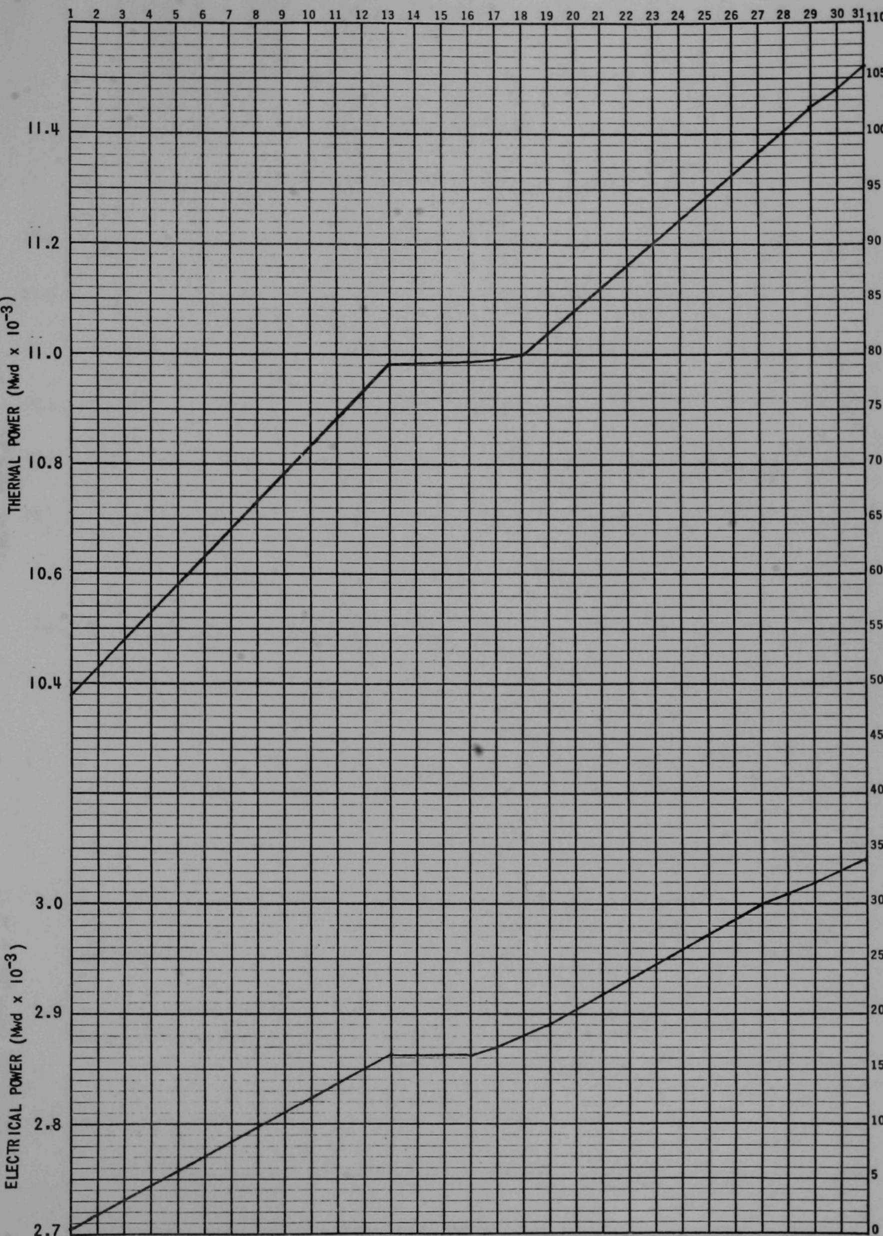
FIG. 6



INTEGRATED THERMAL AND ELECTRICAL POWER

Month DECEMBER 19 66

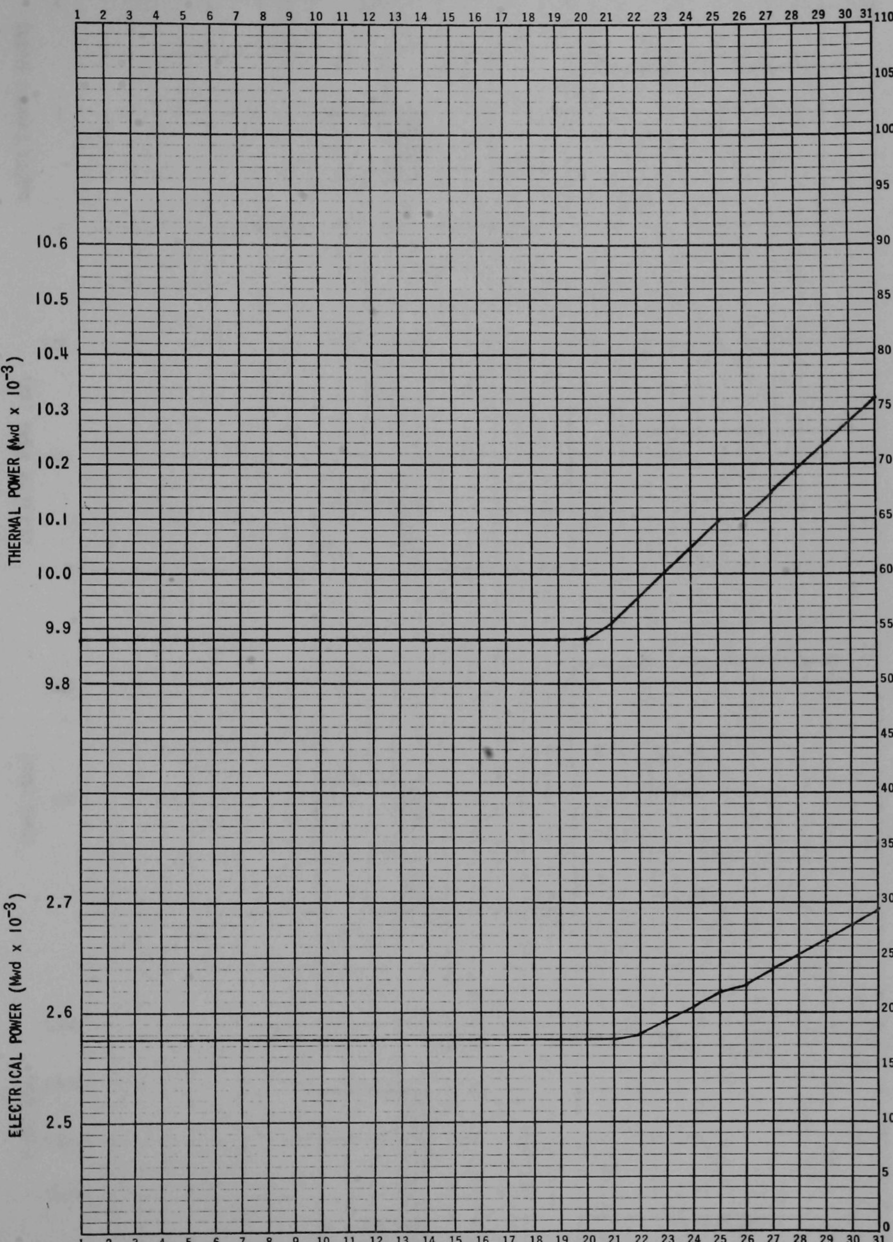
FIG. 7



INTEGRATED THERMAL AND ELECTRICAL POWER

Month NOVEMBER 1966

FIG. 8



INTEGRATED THERMAL AND ELECTRICAL POWER

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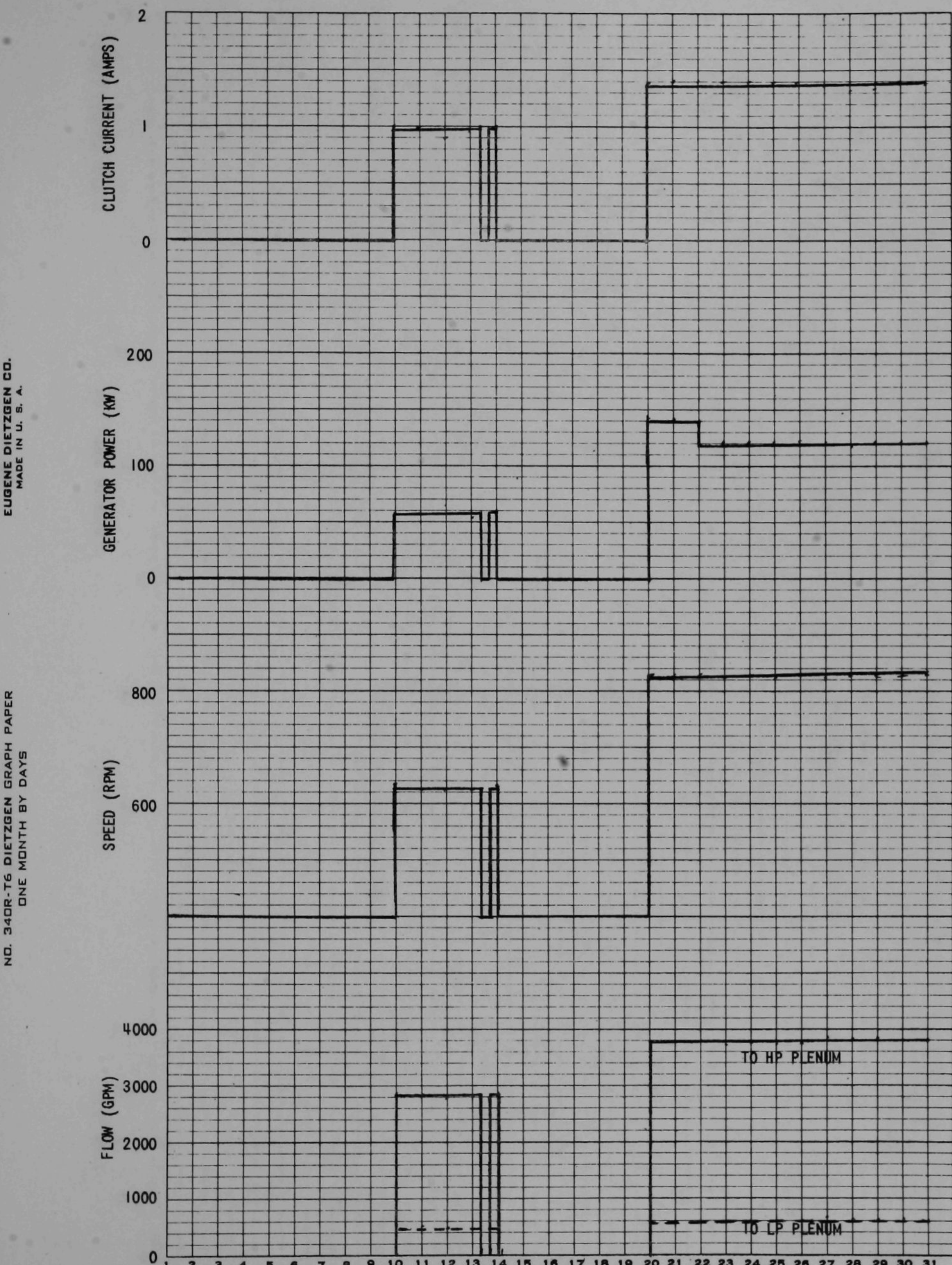
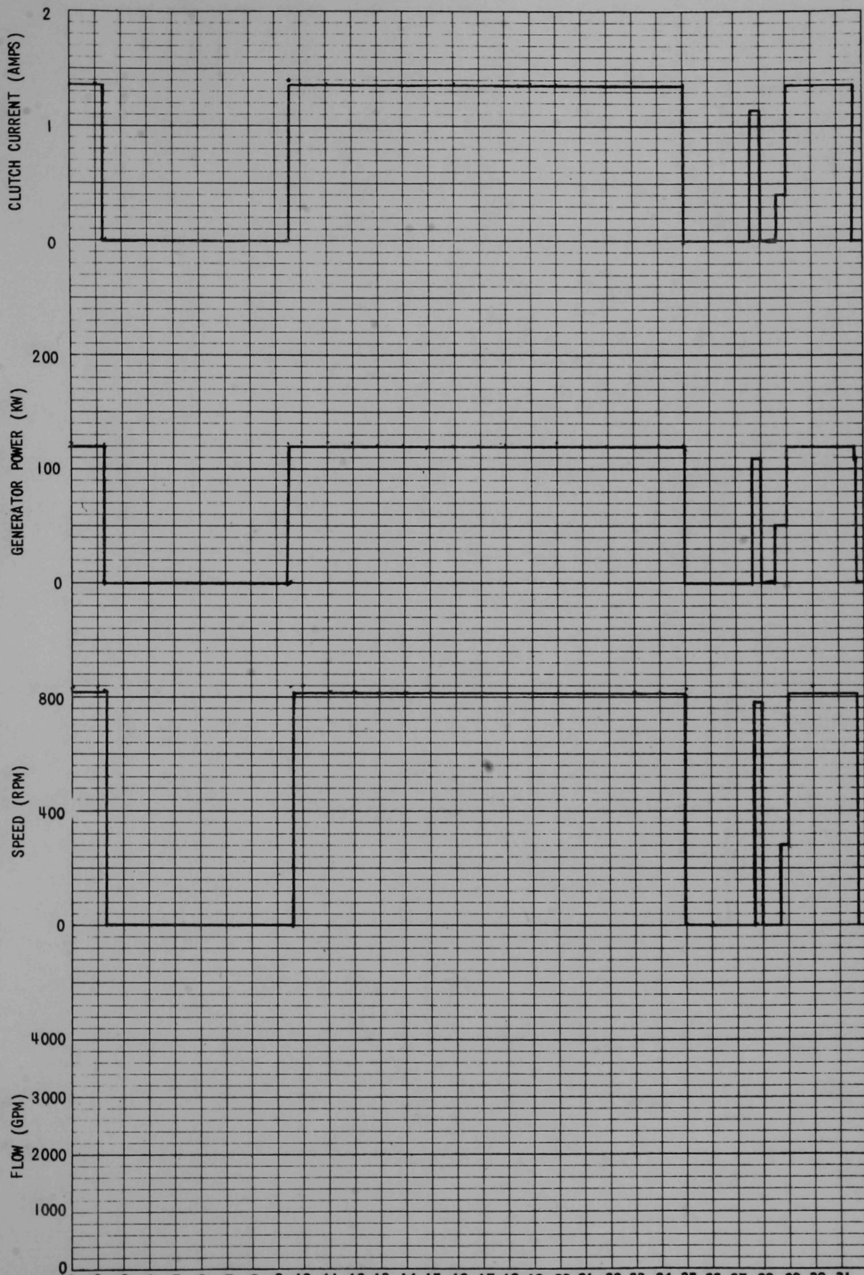
FIG. 9



PRIMARY PUMP #1 PARAMETERS

MONTH OCTOBER 19 66

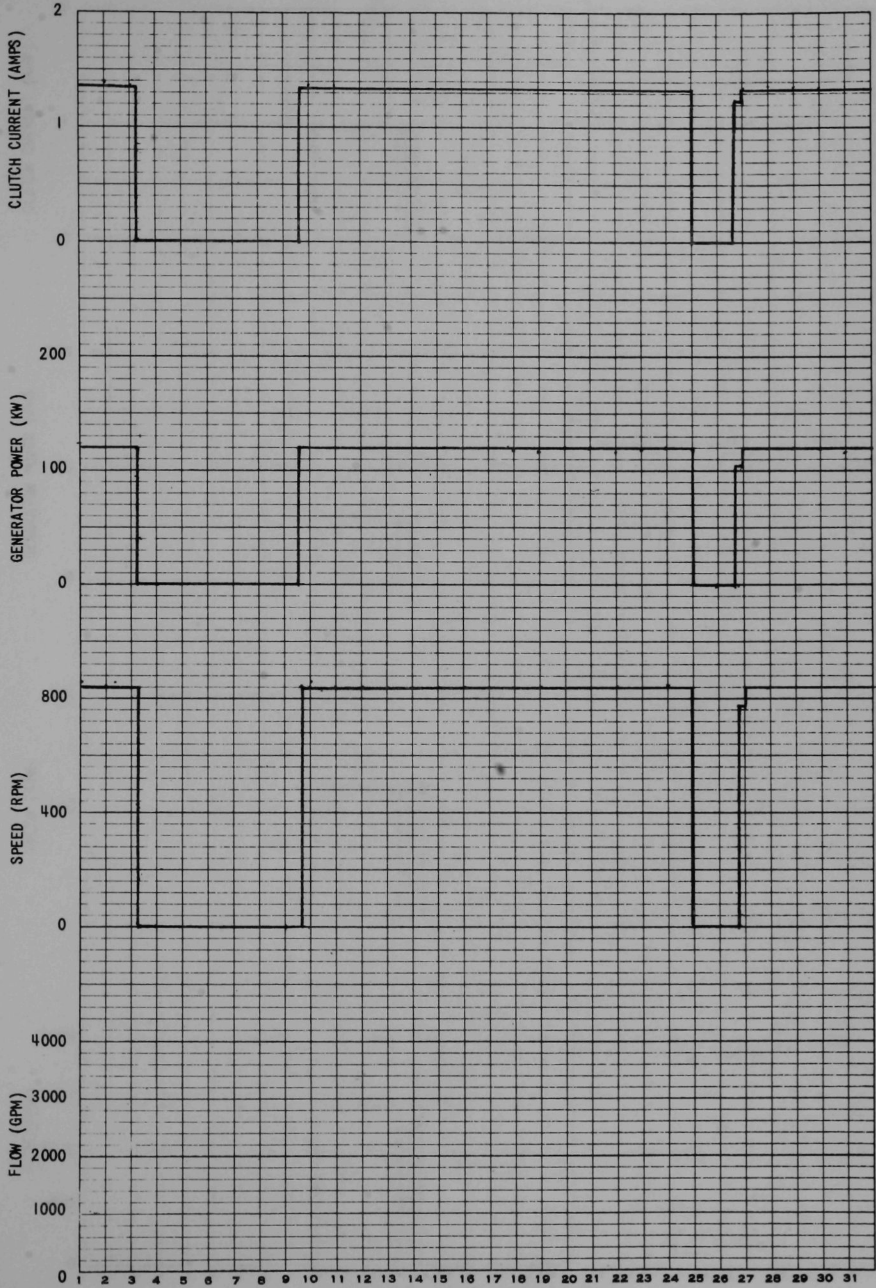
FIG. 10



PRIMARY PUMP #1 PARAMETERS

MONTH DECEMBER 19 66

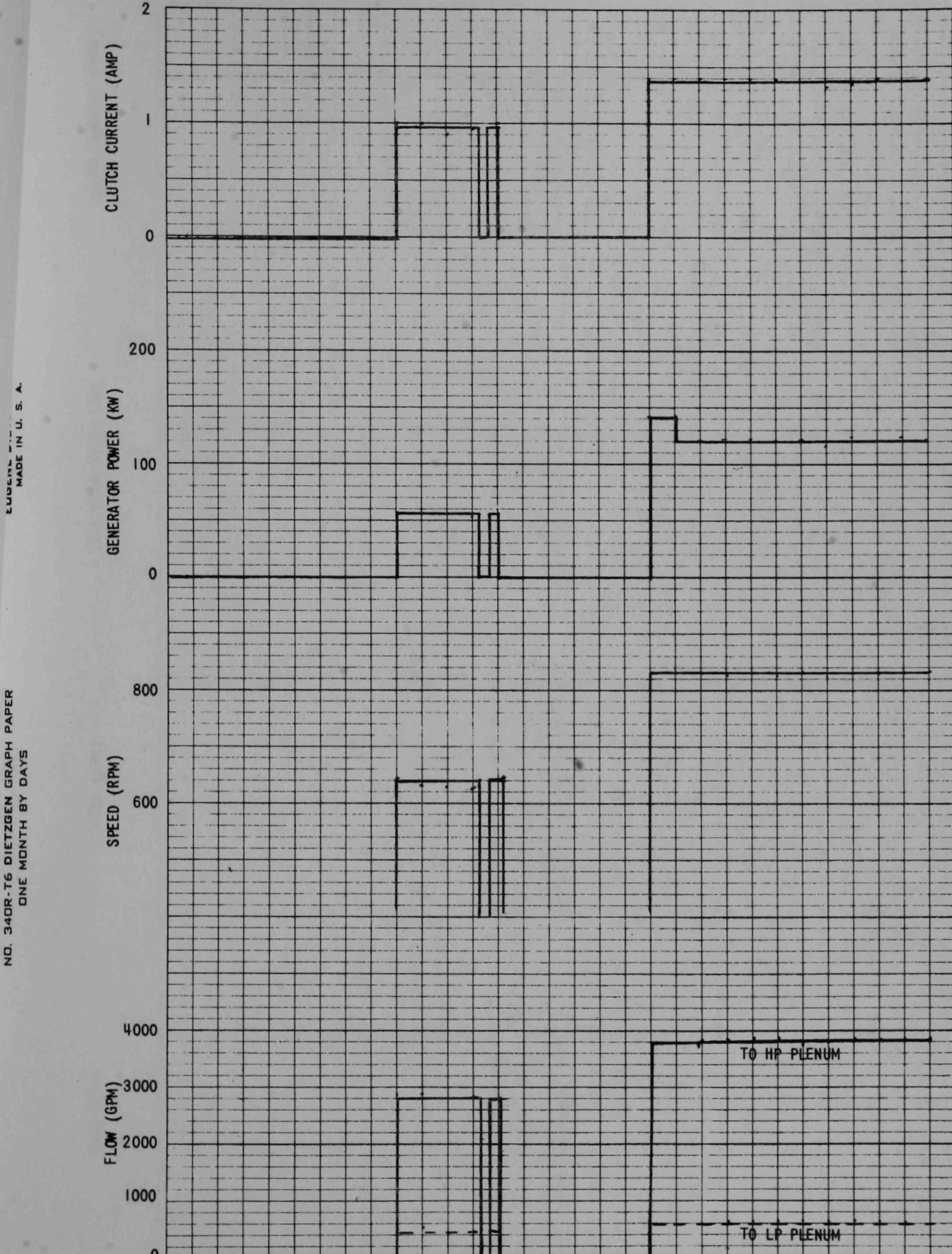
FIG. 11



PRIMARY PUMP #2 PARAMETERS

MONTH DECEMBER 1966

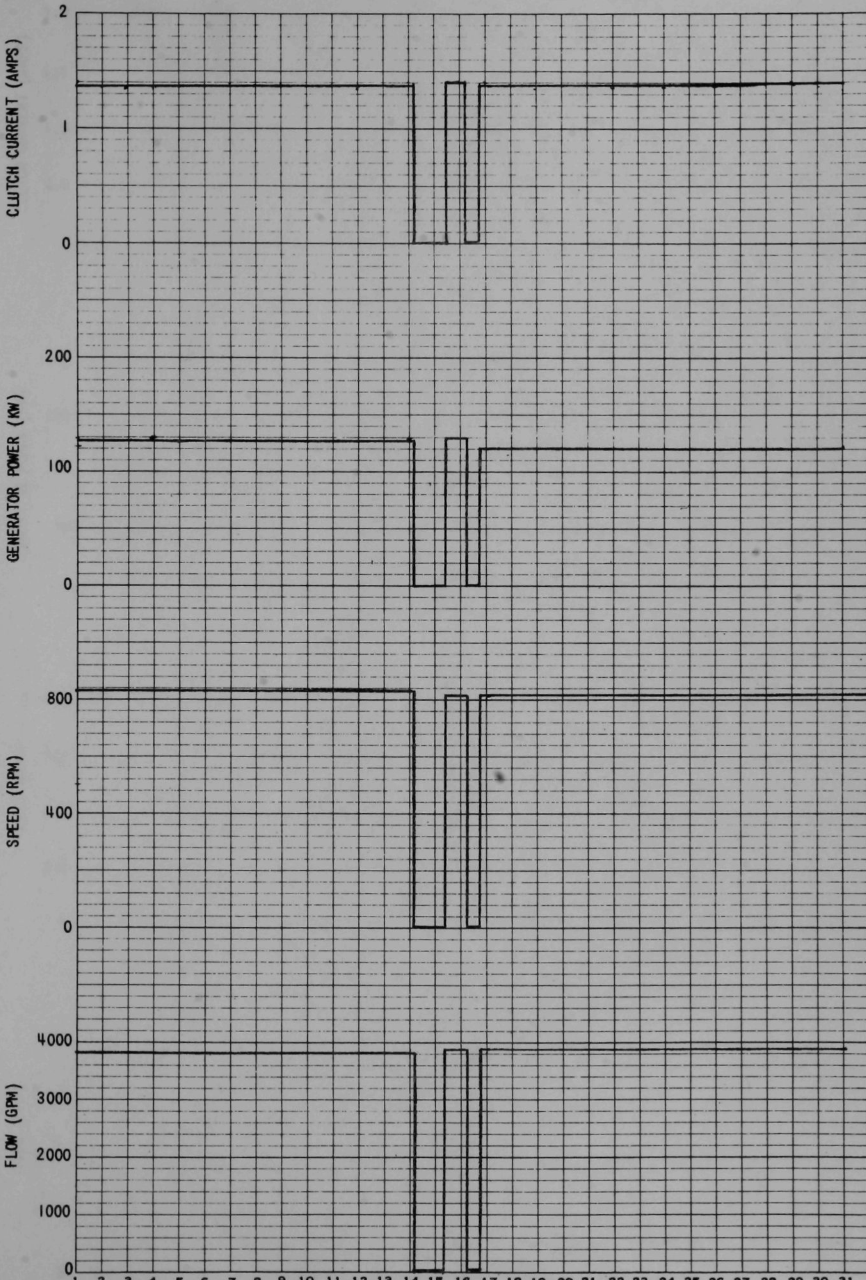
FIG. 12



PRIMARY PUMP #2 PARAMETERS

MONTH OCTOBER 19 66

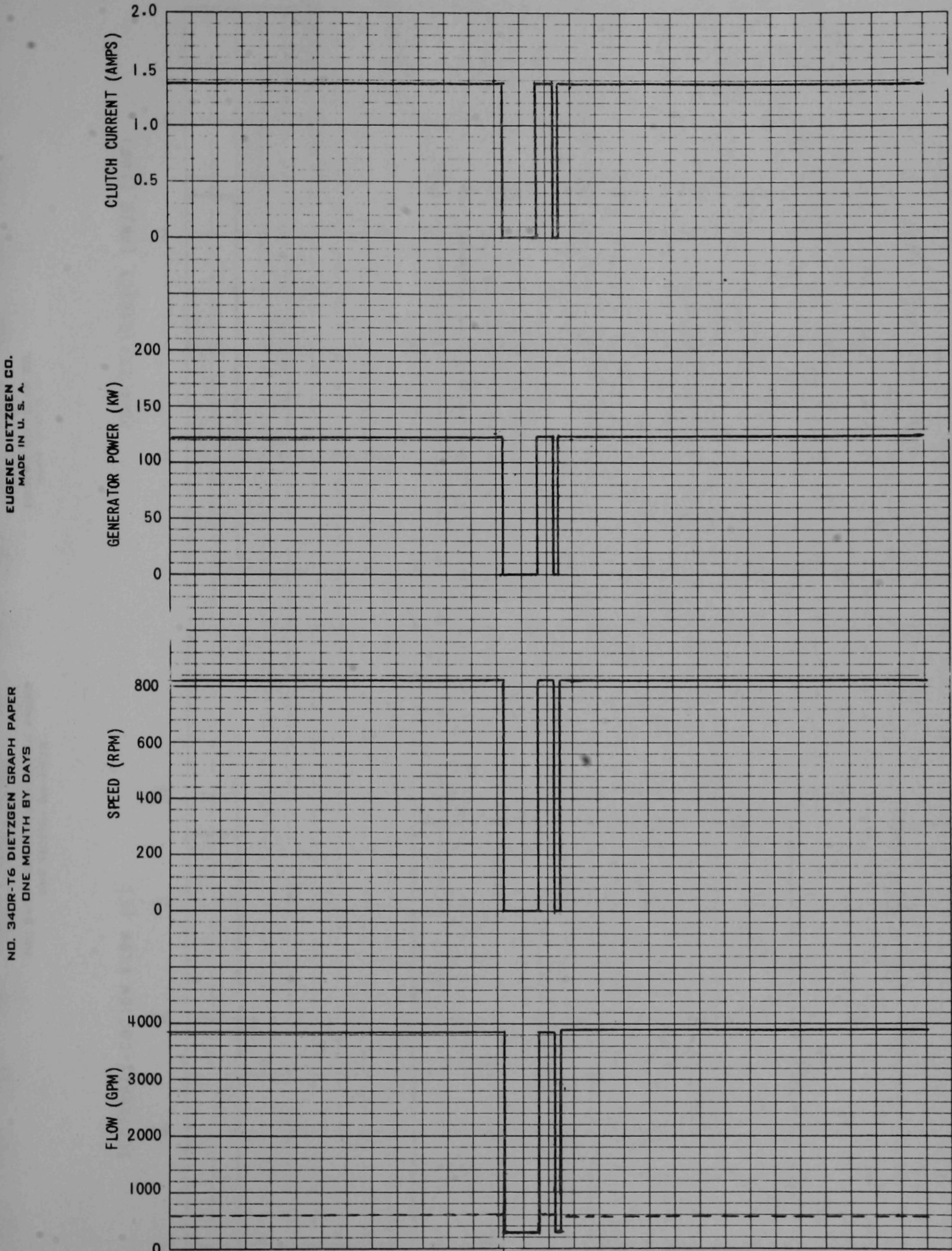
FIG. 13



PRIMARY PUMP #1 PARAMETERS

MONTH NOVEMBER 19 66

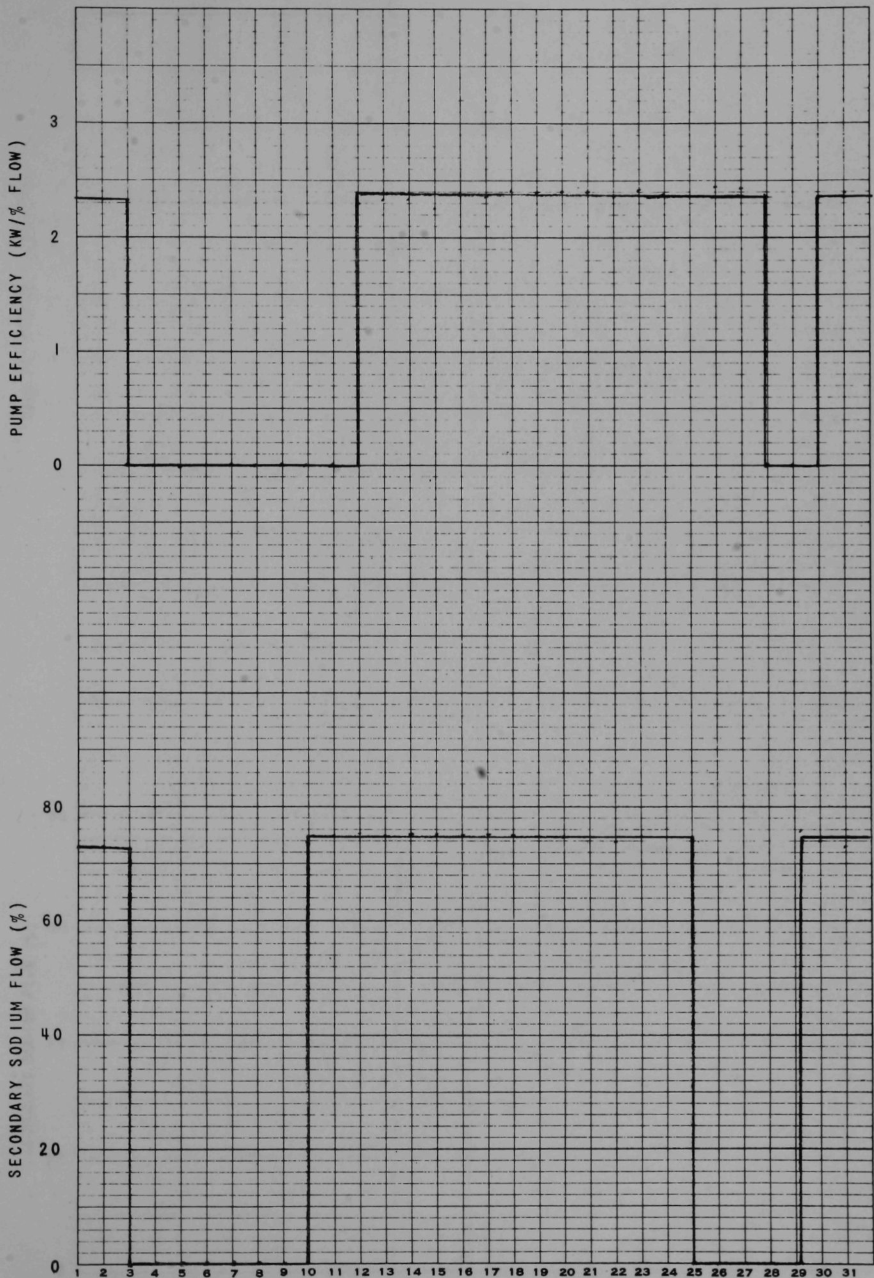
FIG. 14



PRIMARY PUMP NO. 2 PARAMETERS

MONTH NOVEMBER 19 66

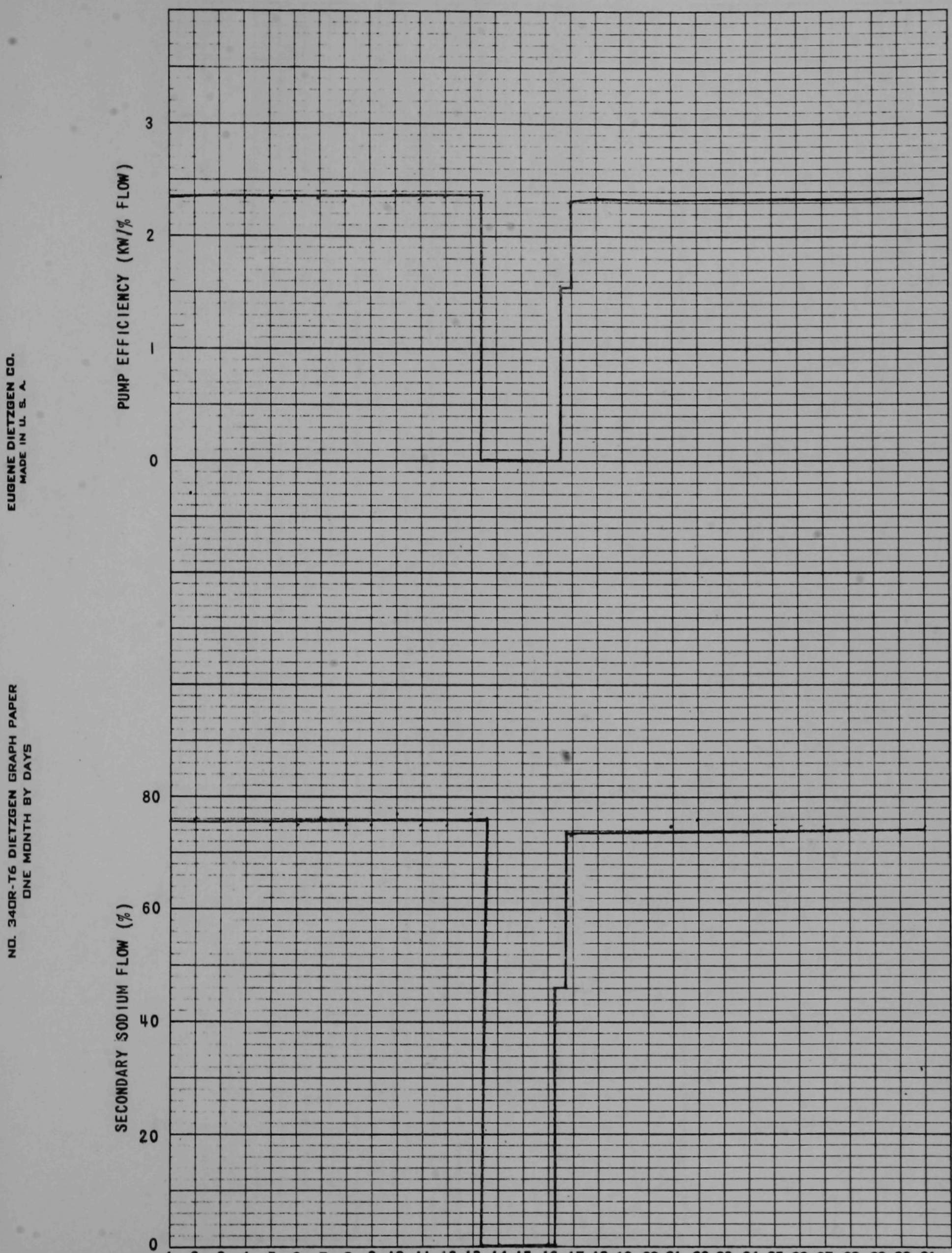
FIG. 15



SECONDARY SODIUM FLOW AND SECONDARY PUMP EFFICIENCY

MONTH DECEMBER 19 66

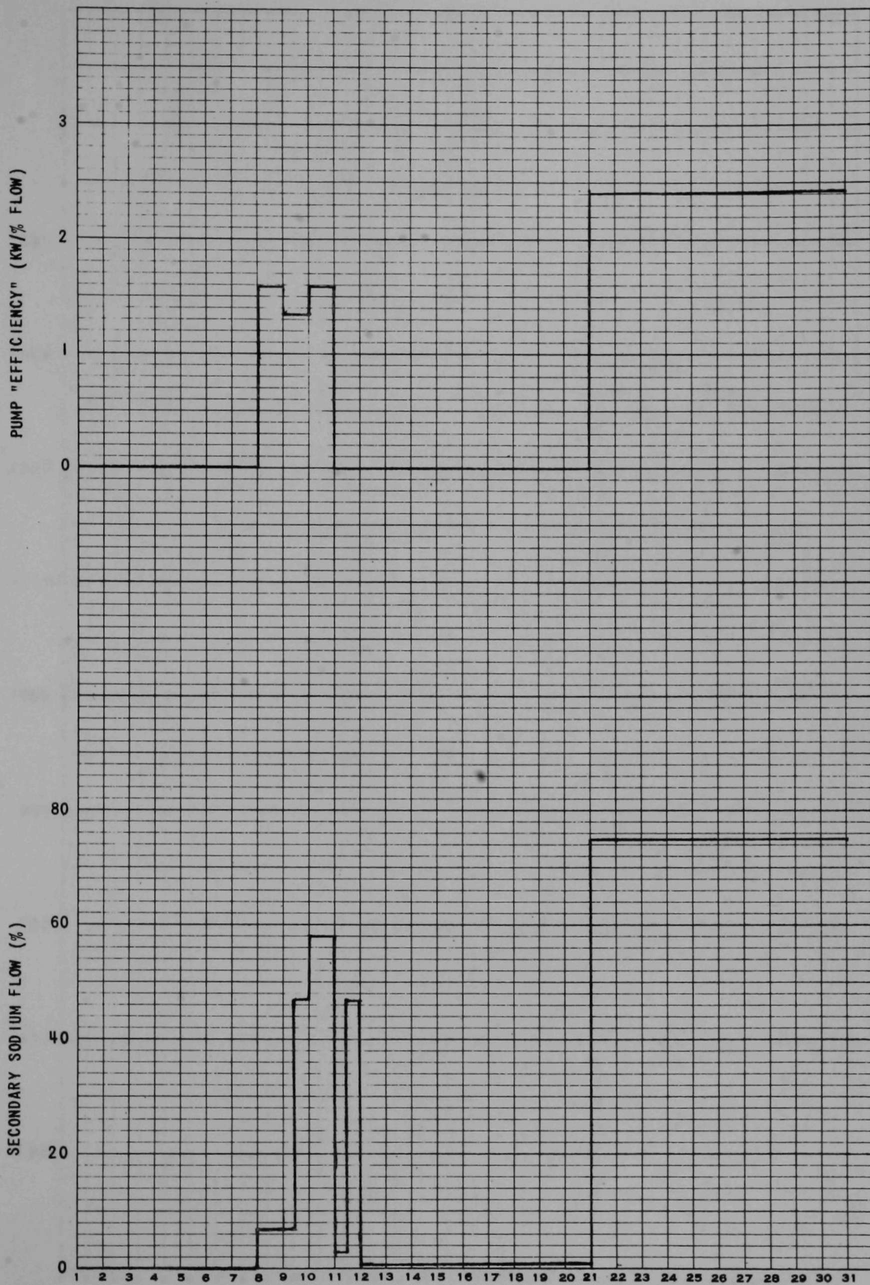
FIG. 16



SECONDARY SODIUM FLOW AND SECONDARY PUMP EFFICIENCY

MONTH NOVEMBER 1966

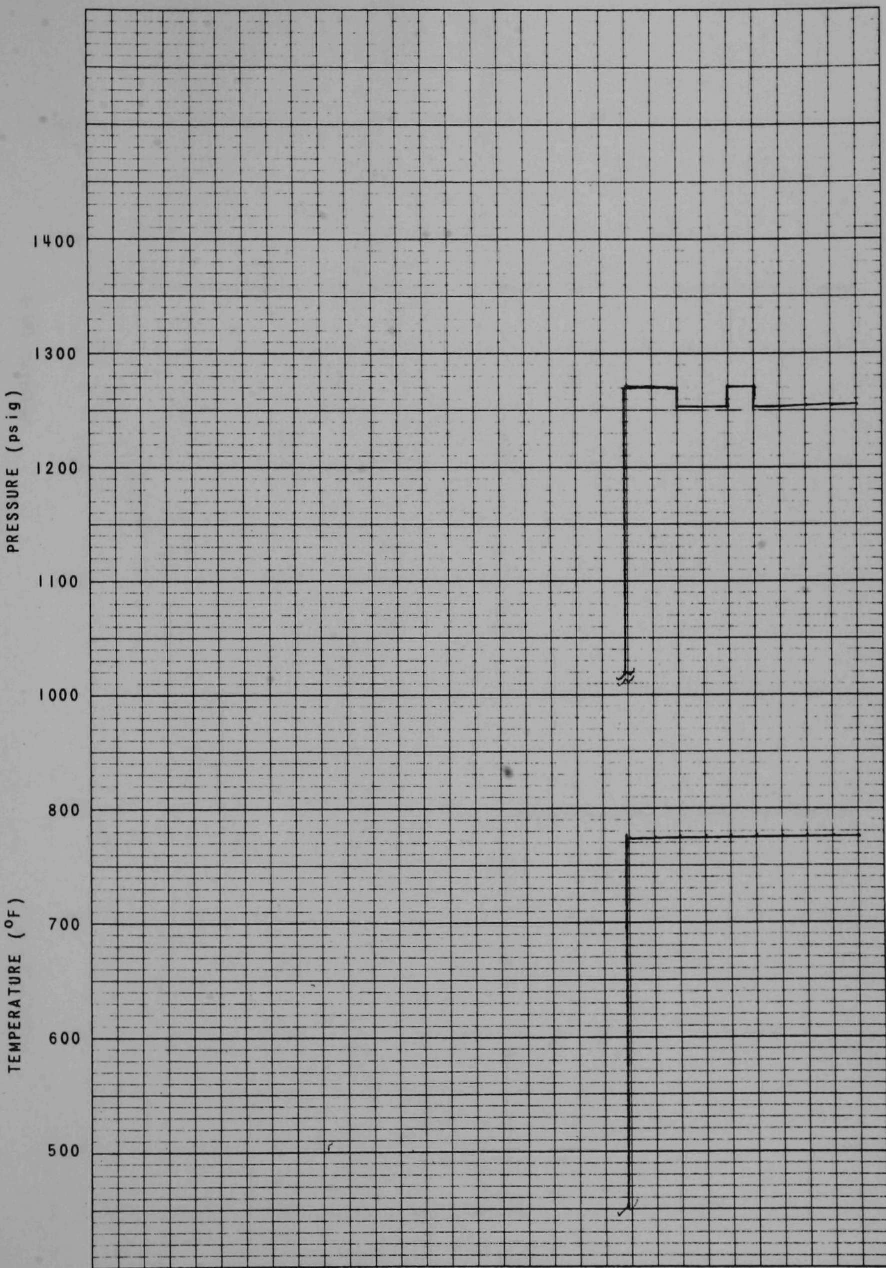
FIG. 17



SECONDARY SODIUM FLOW AND SECONDARY PUMP EFFICIENCY

MONTH OCTOBER 1966

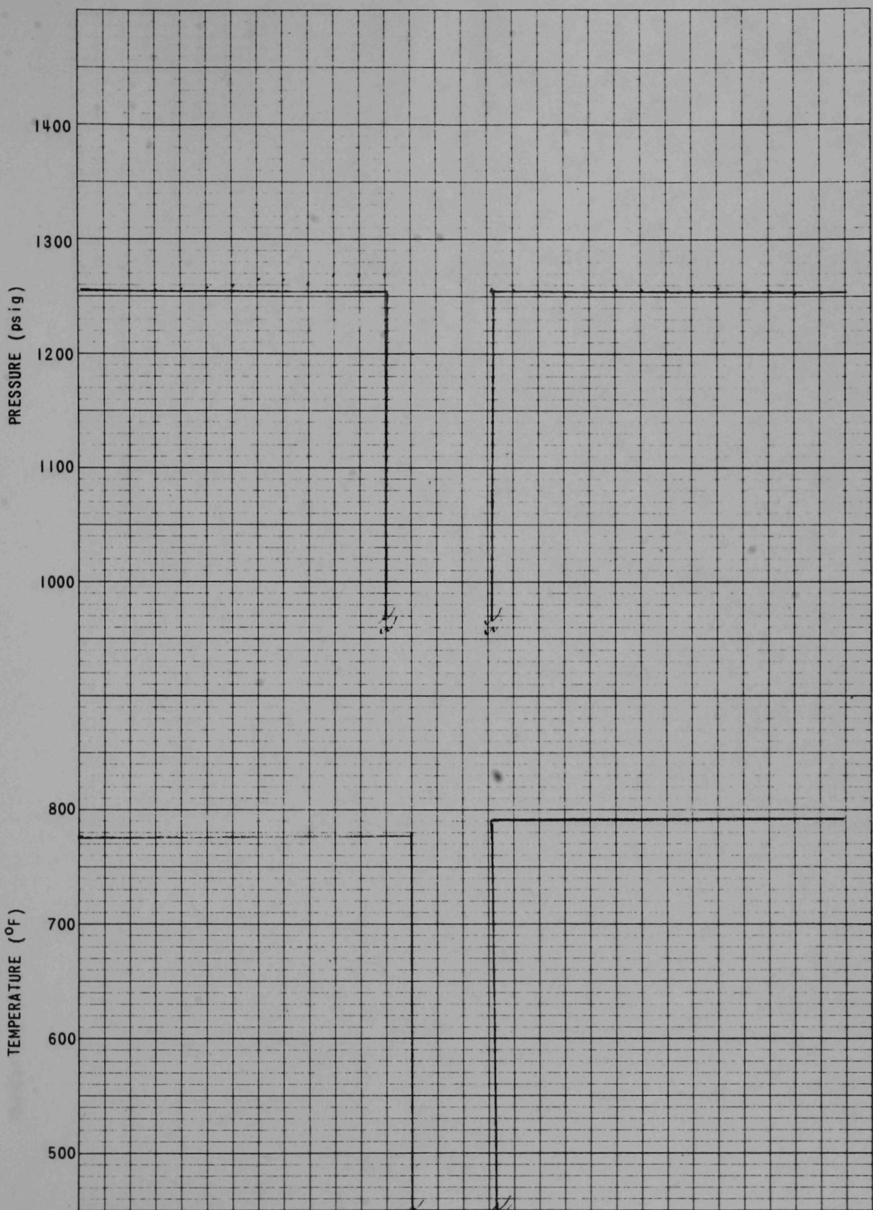
FIG. 18



STEAM HEADER TEMPERATURE AND PRESSURE

MONTH OCTOBER 19 66

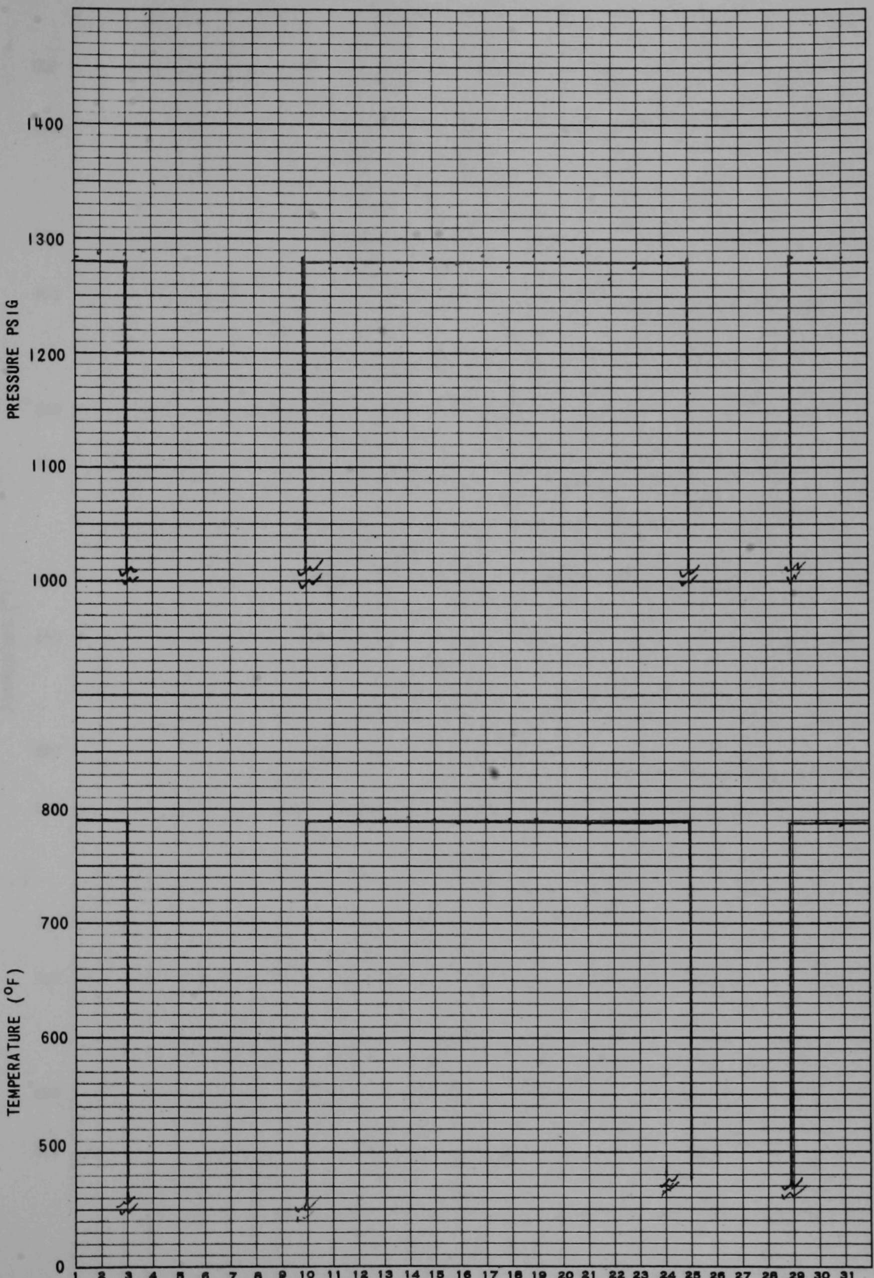
FIG. 19



STEAM HEADER TEMPERATURE AND PRESSURE

MONTH NOVEMBER 19 66

FIG. 20



STEAM HEADER TEMPERATURE & PRESSURE

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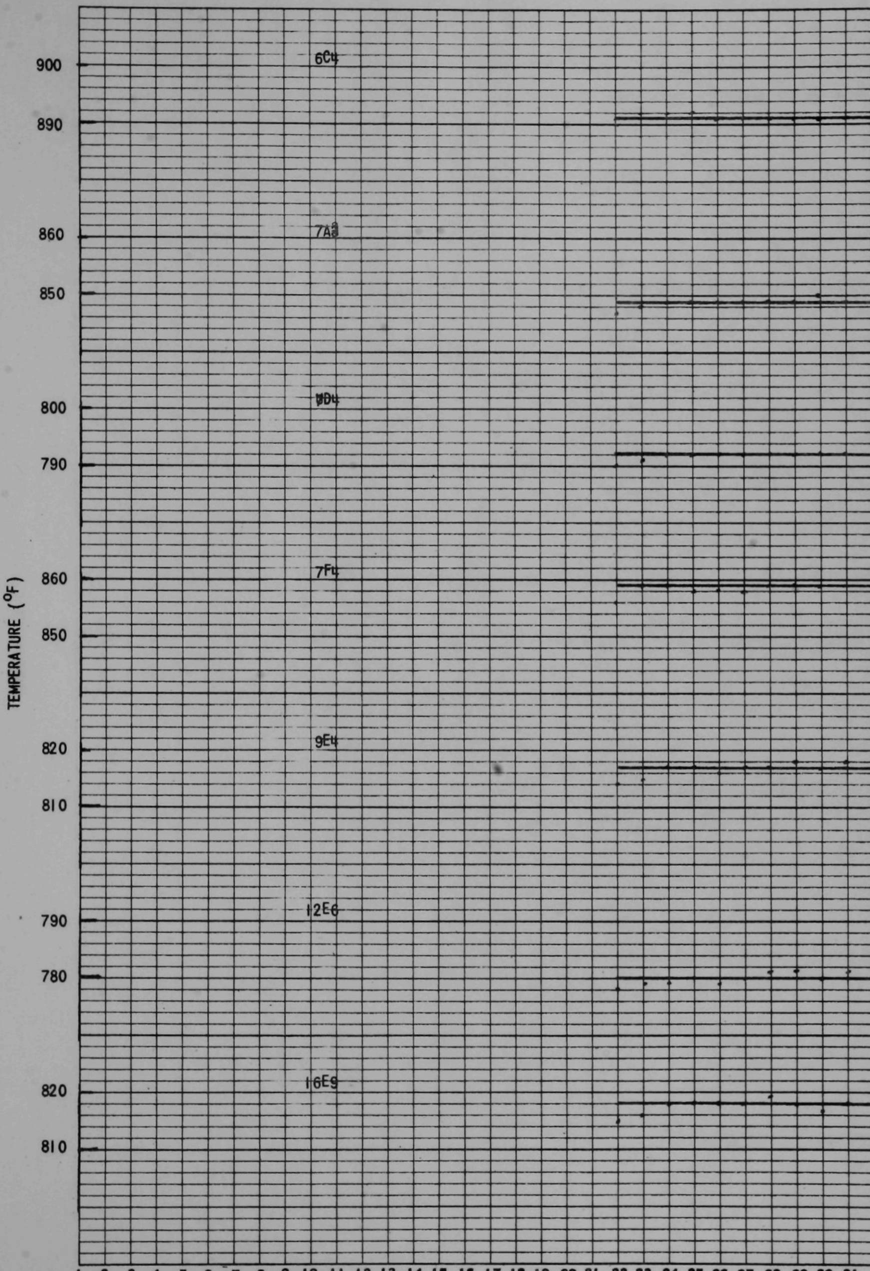
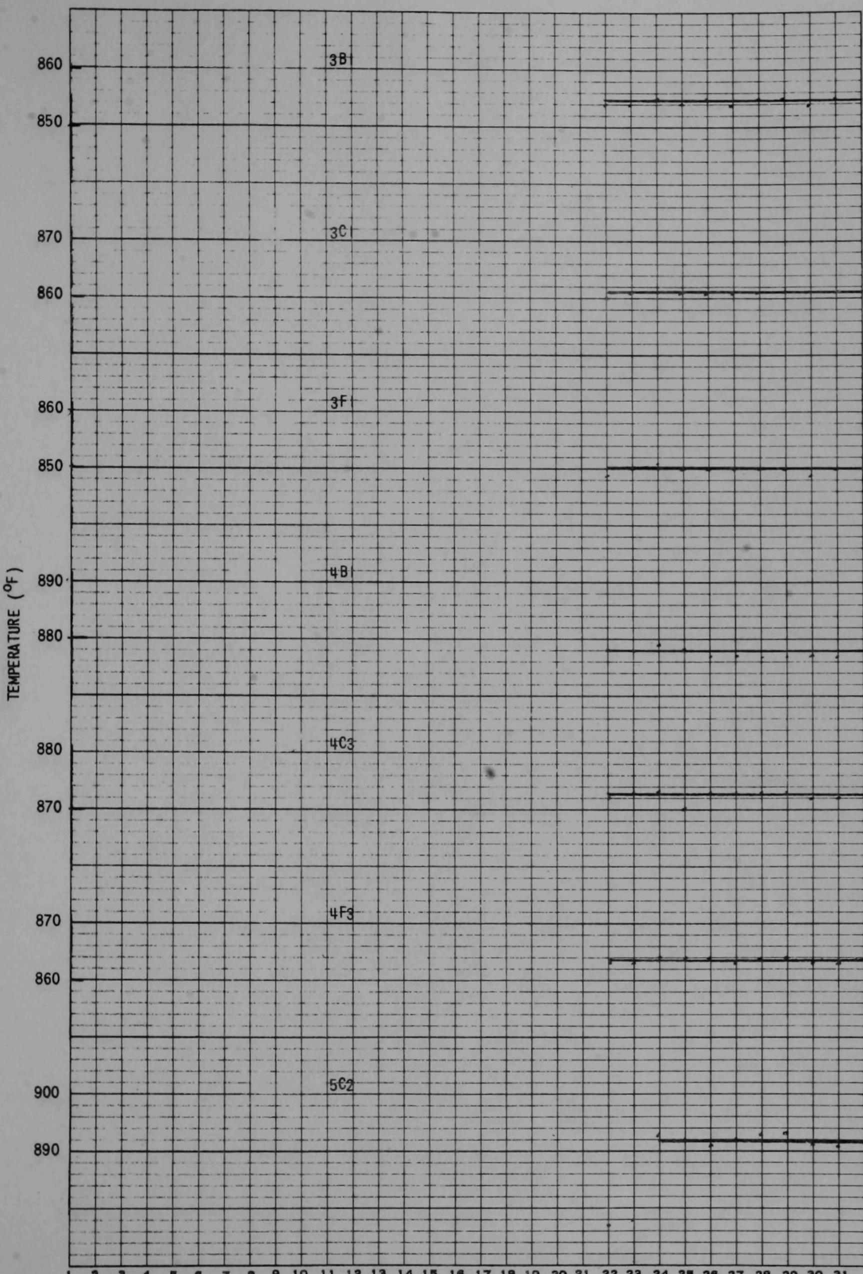
FIG. 21



STEADY STATE SUBASSEMBLY OUTLET TEMPERATURES

MONTH OCTOBER 19 66

FIG. 22



STEADY STATE SUBASSEMBLY OUTLET TEMPERATURES

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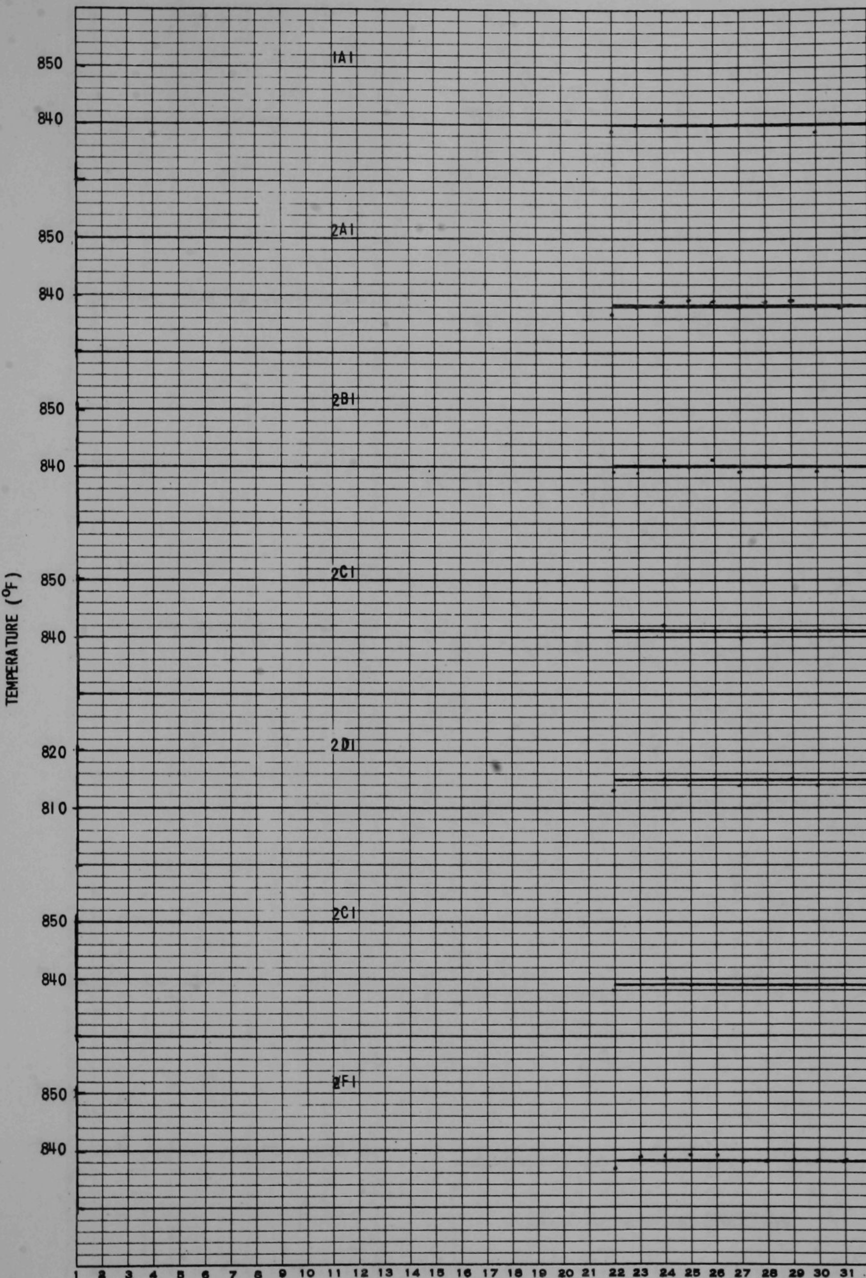
FIG. 23



STEADY STATE SUBASSEMBLY OUTLET TEMPERATURES

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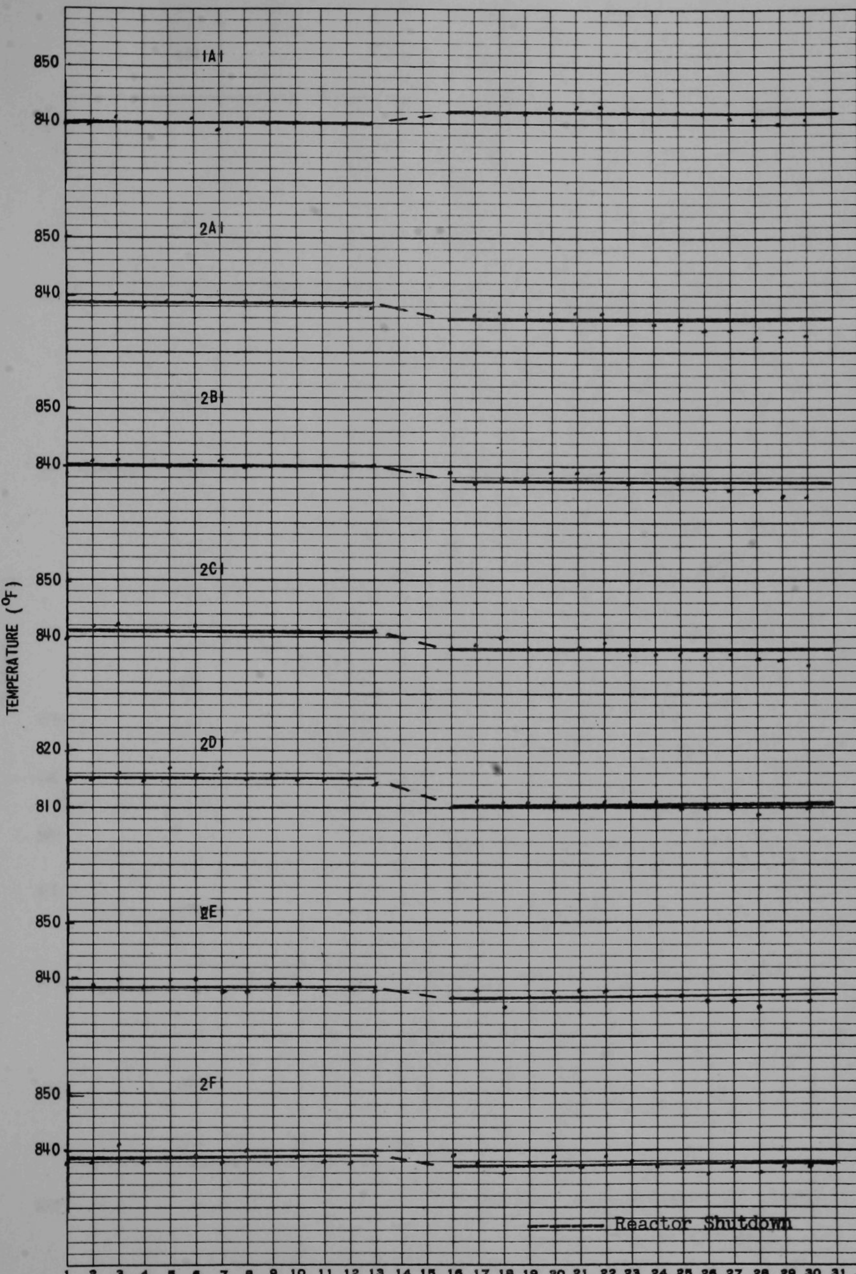
FIG. 24



STEADY STATE SUBASSEMBLY OUTLET TEMPERATURES

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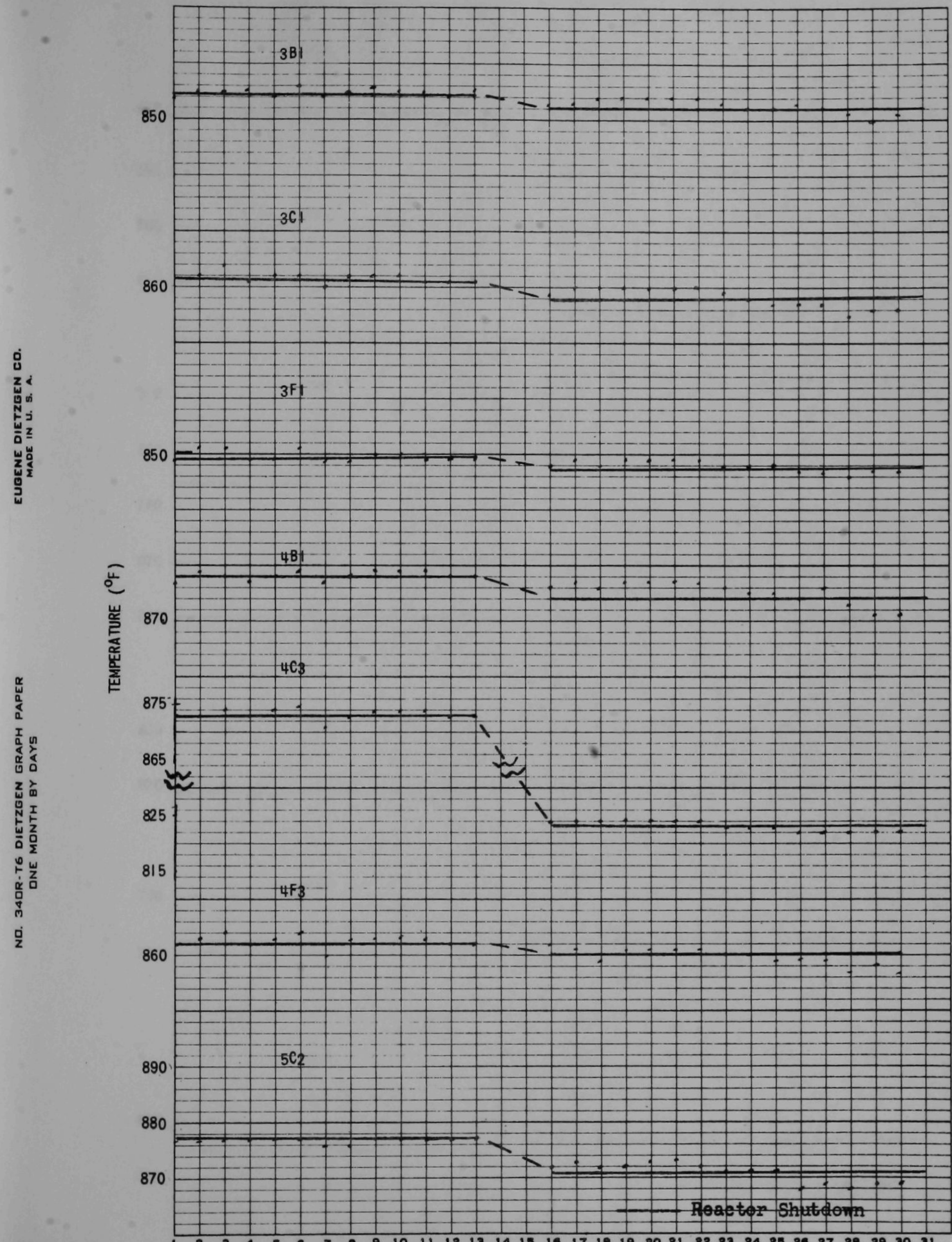
FIG. 25



STEADY STATE SUBASSEMBLY OUTLET TEMPERATURES

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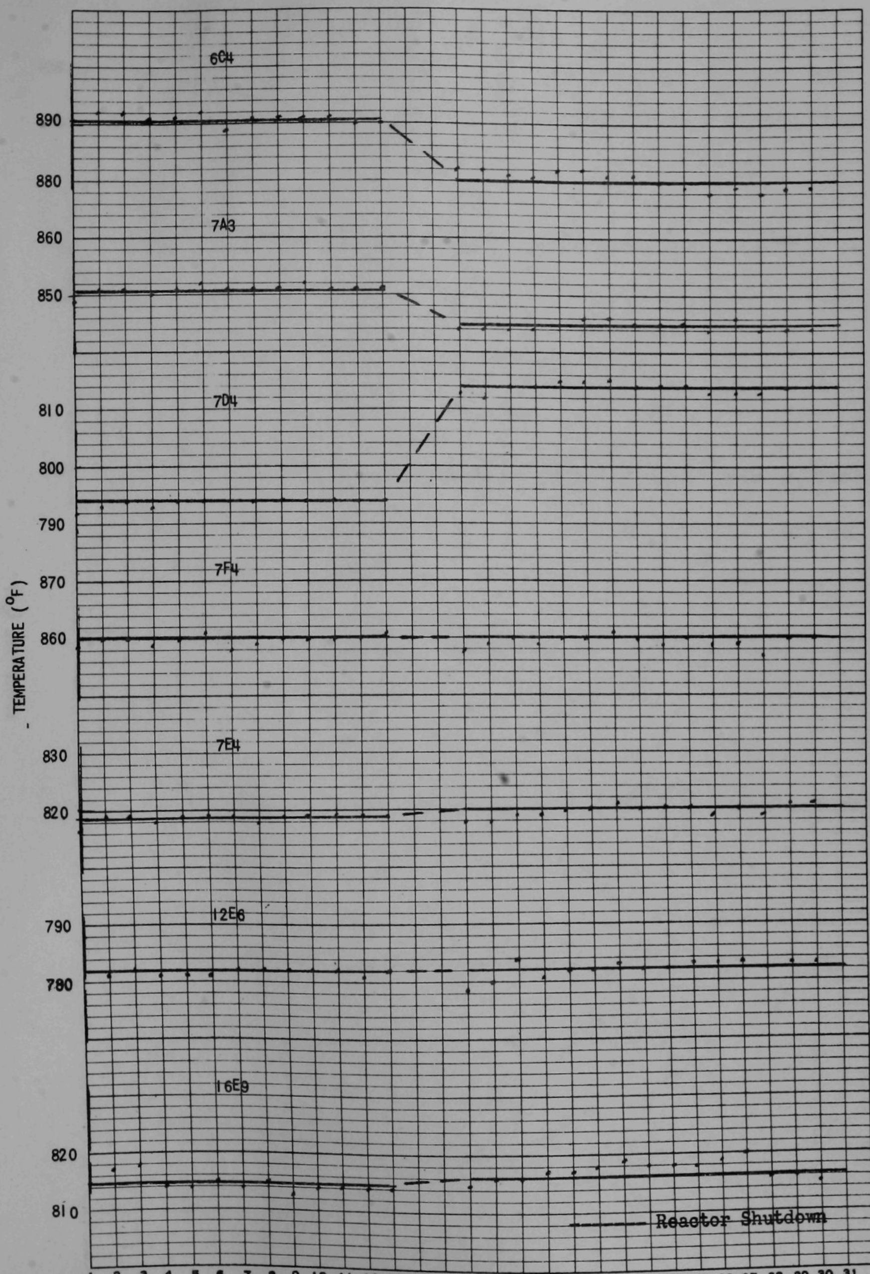
FIG. 26



STEADY STATE SUBASSEMBLY OUTLET TEMPERATURES

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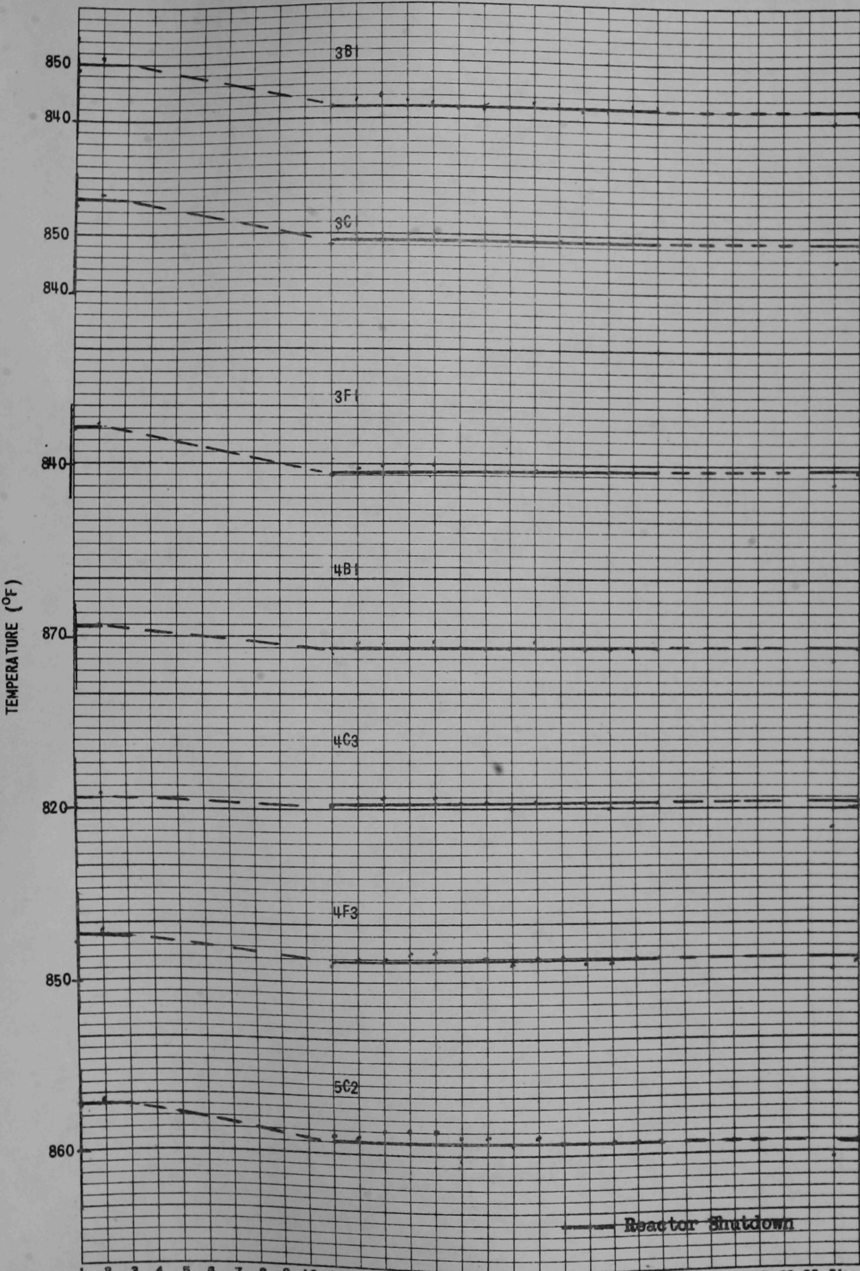
FIG. 27



STEADY STATE SUBASSEMBLY OUTLET TEMPERATURES

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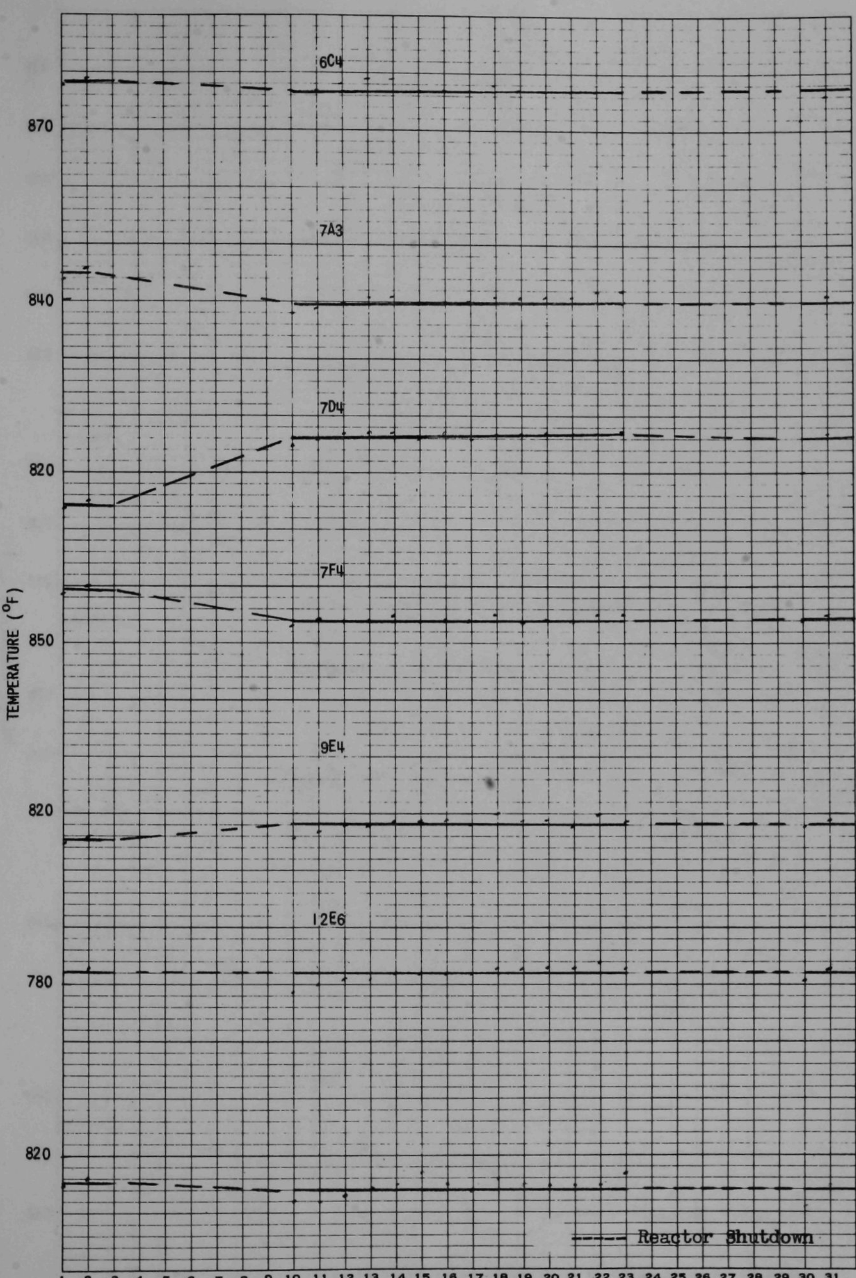
FIG. [illegible]



STEADY STATE SUBASSEMBLY OUTLET TEMPERATURES

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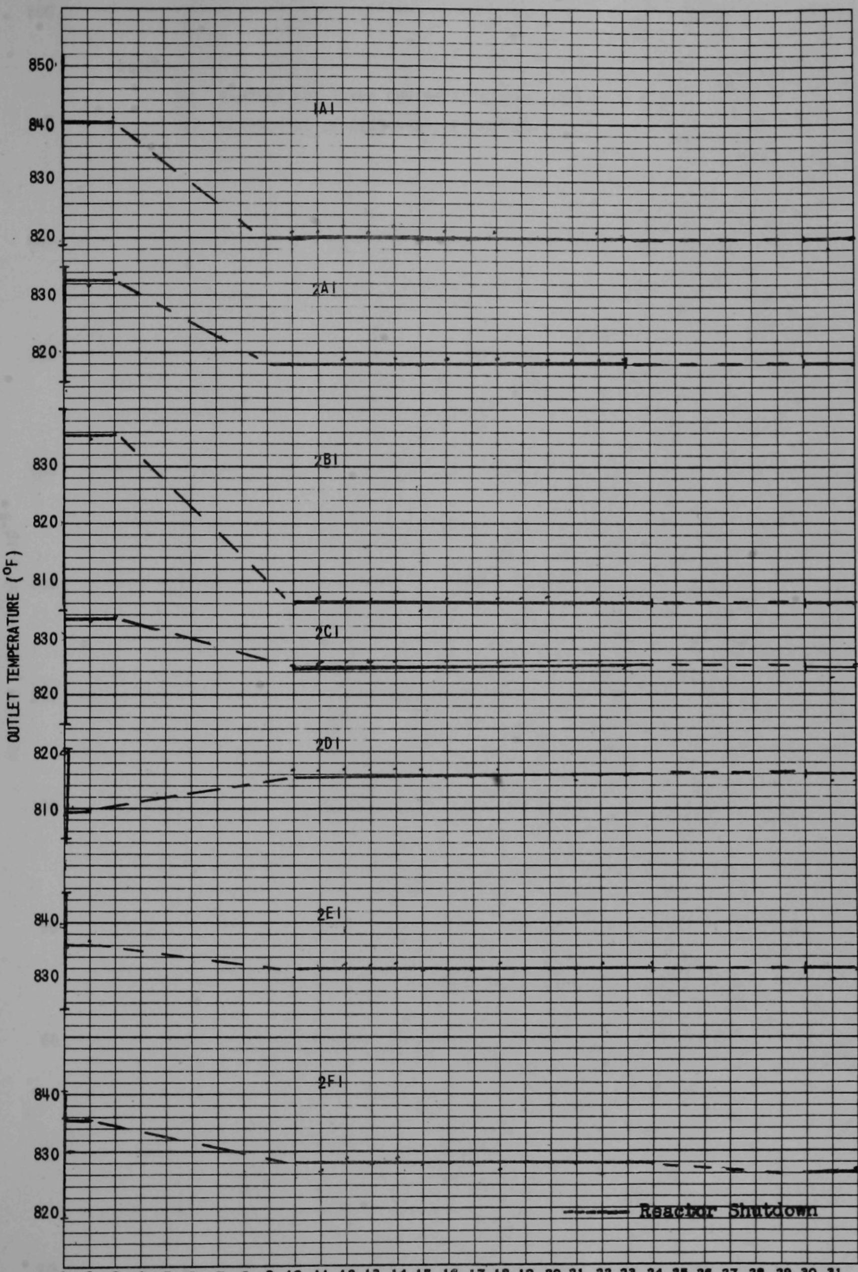
FIG. 29



STEADY STATE SUBASSEMBLY OUTLET TEMPERATURES

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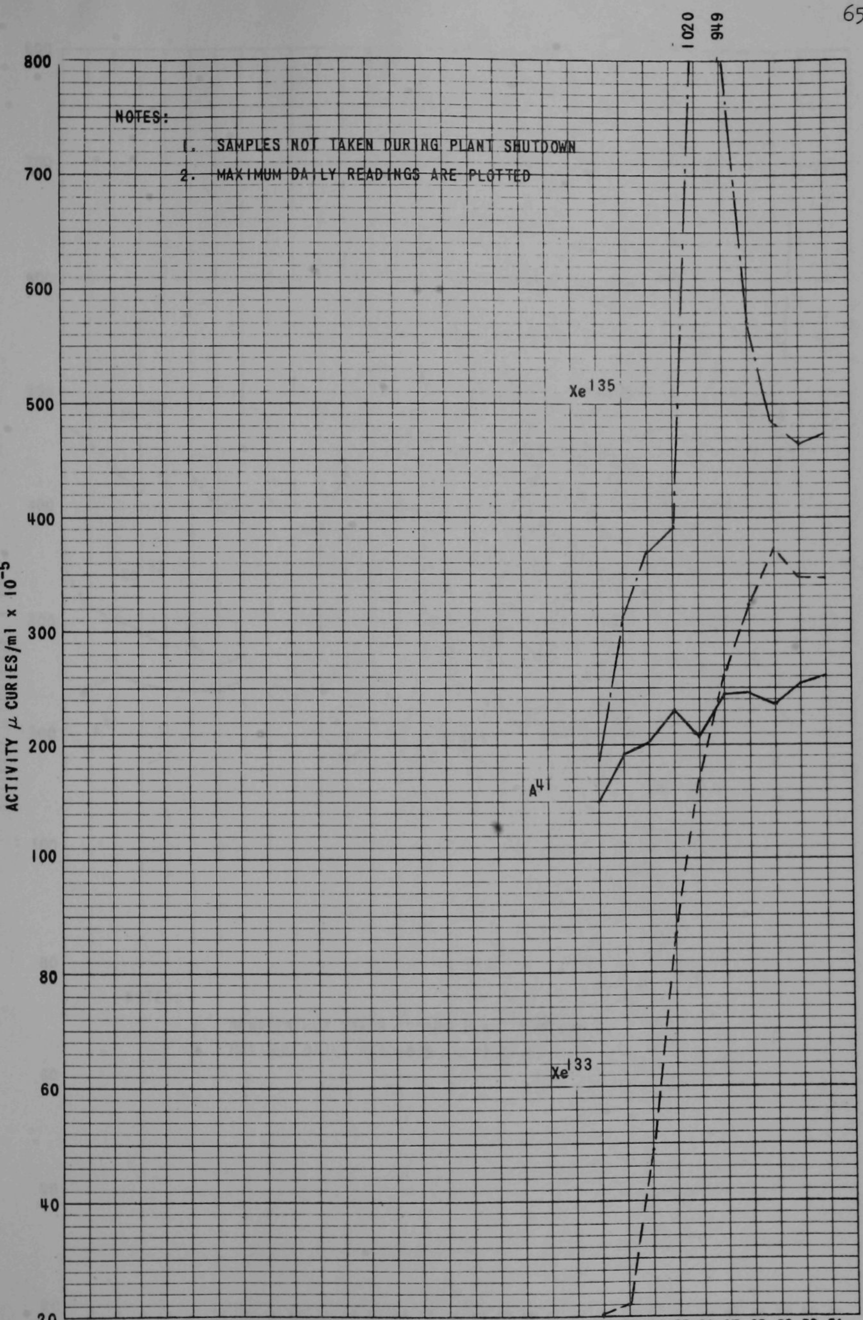
FIG. 30



PRIMARY COVER GAS ACTIVITY

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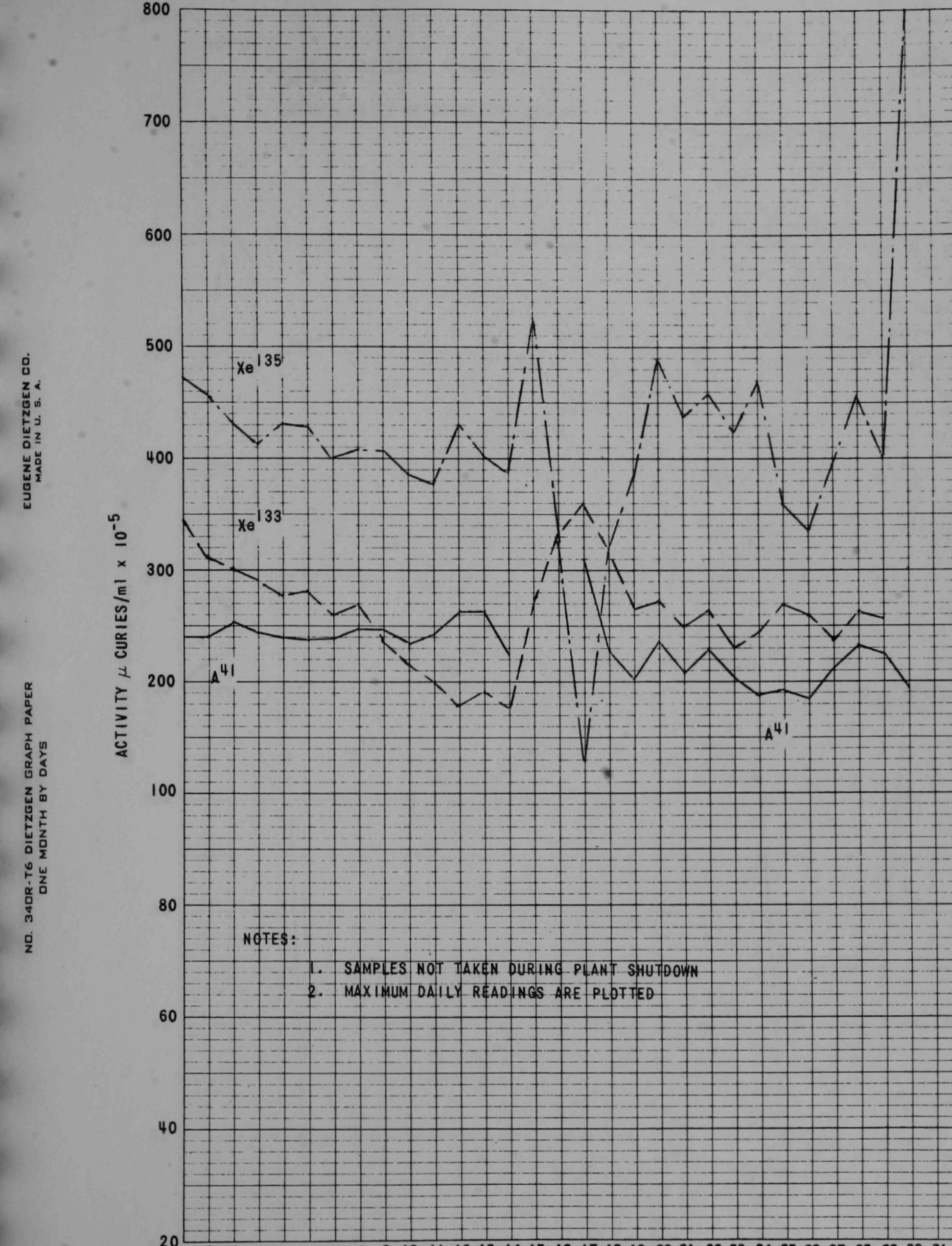
FIG. 31



PRIMARY COVER GAS ACTIVITY

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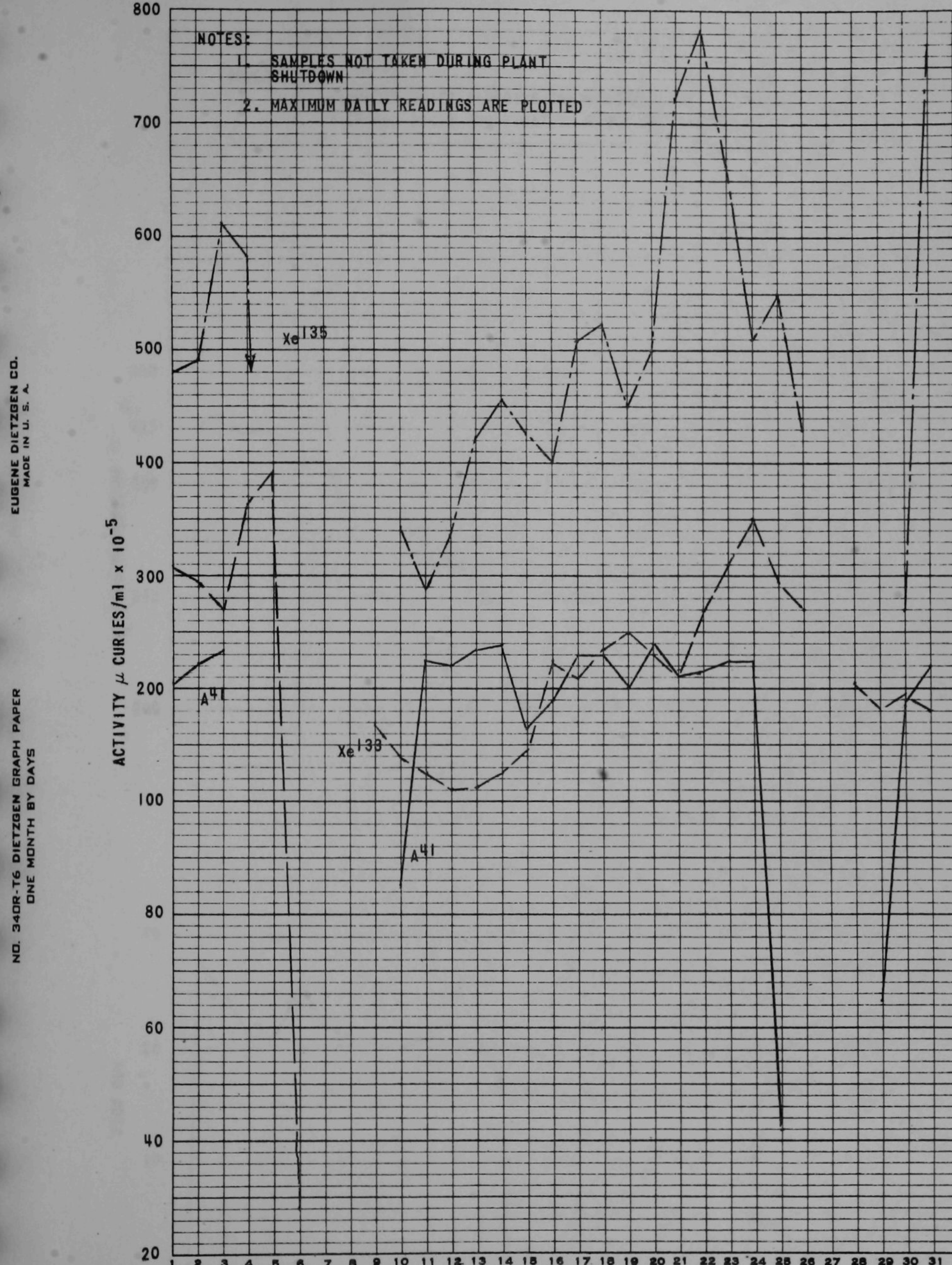
FIG. 32



PRIMARY COVER GAS ACTIVITY

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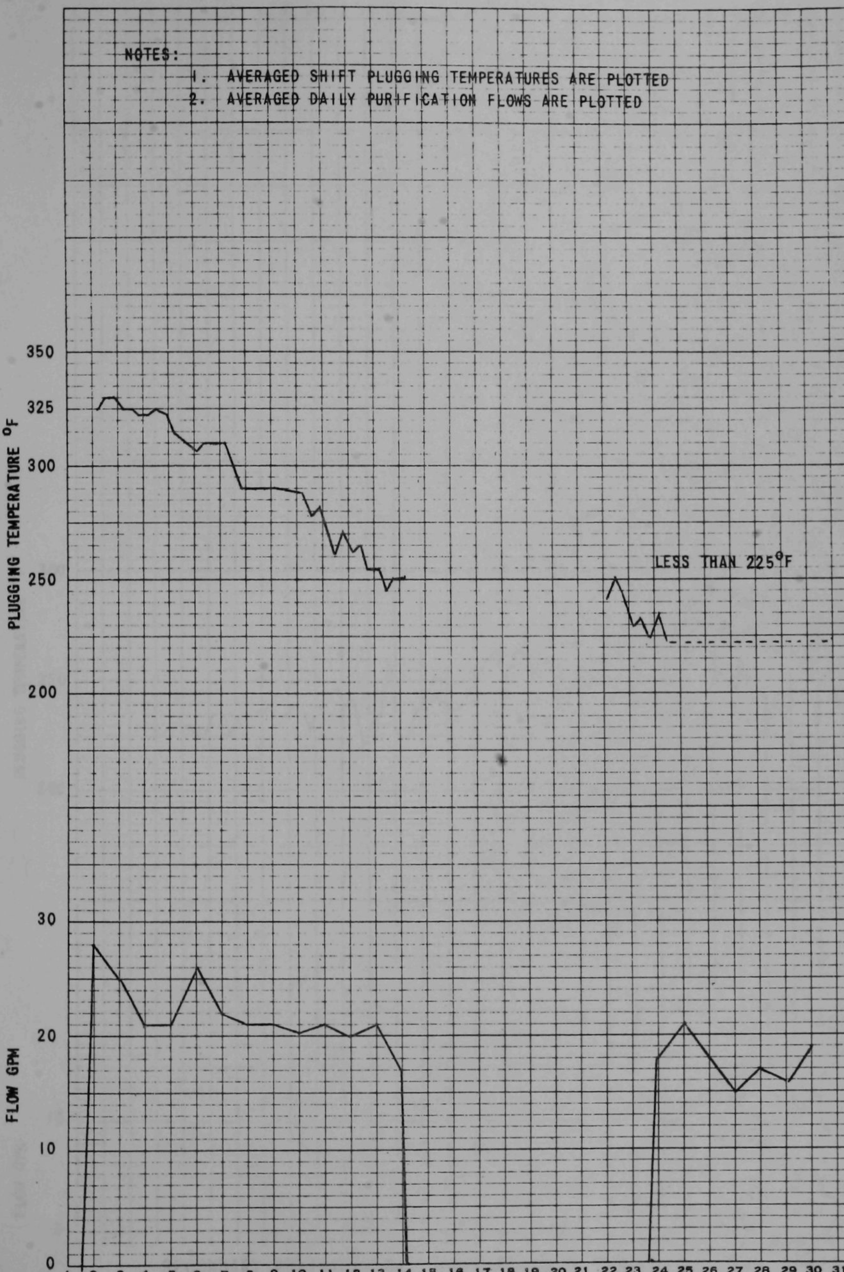
FIG. 33



PRIMARY PURIFICATION SYSTEM PLUGGING TEMPERATURE AND FLOW

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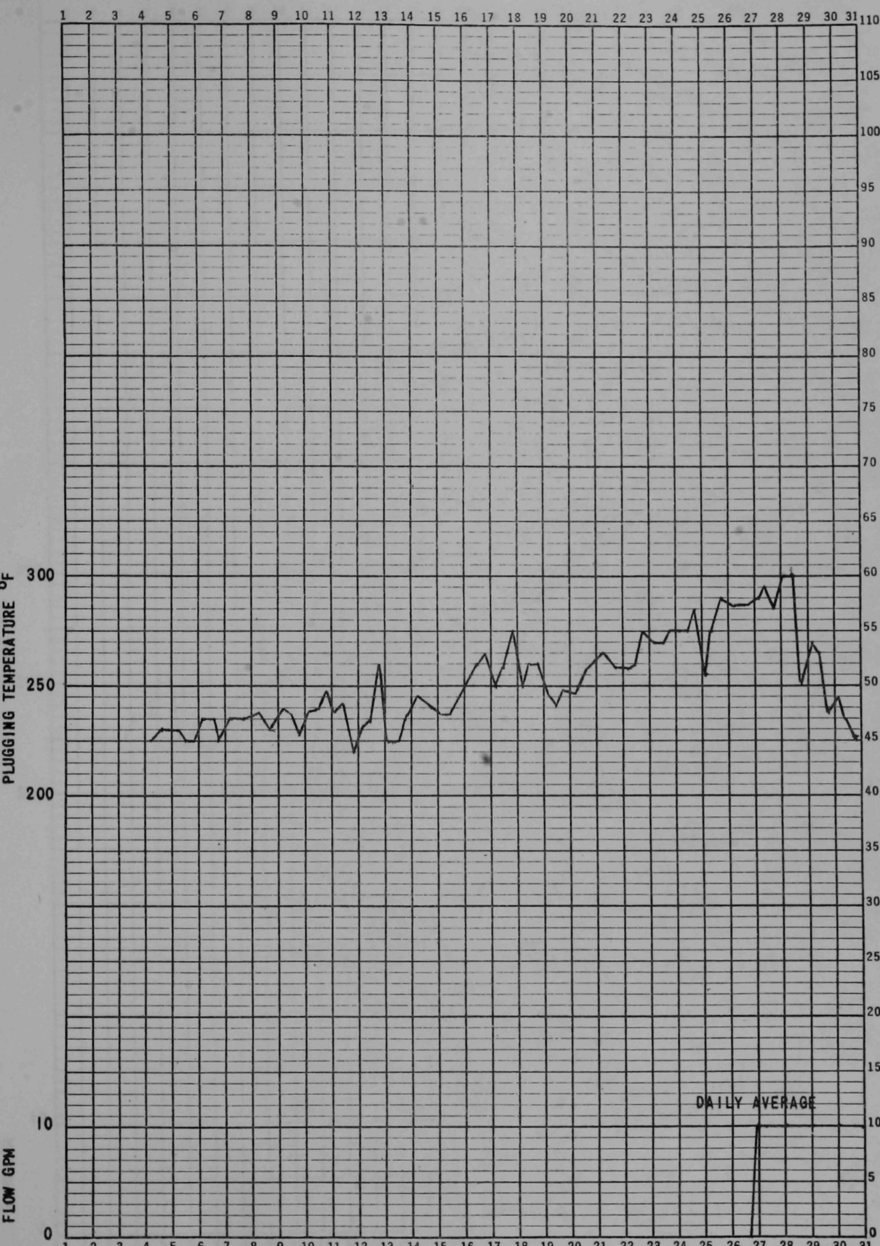
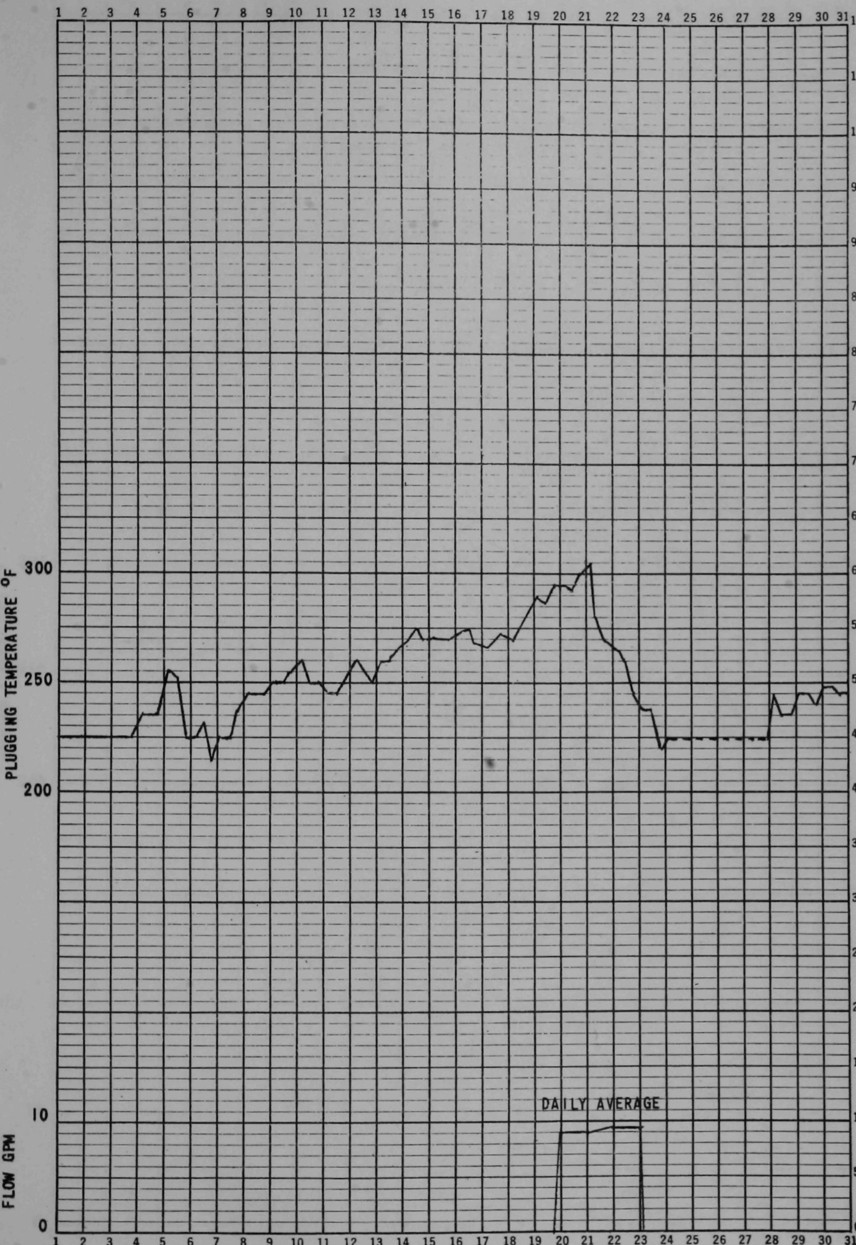
FIG. 2[illegible]



SECONDARY PURIFICATION SYSTEM PLUGGING TEMPERATURE AND FLOW

Month OCTOBER 1966

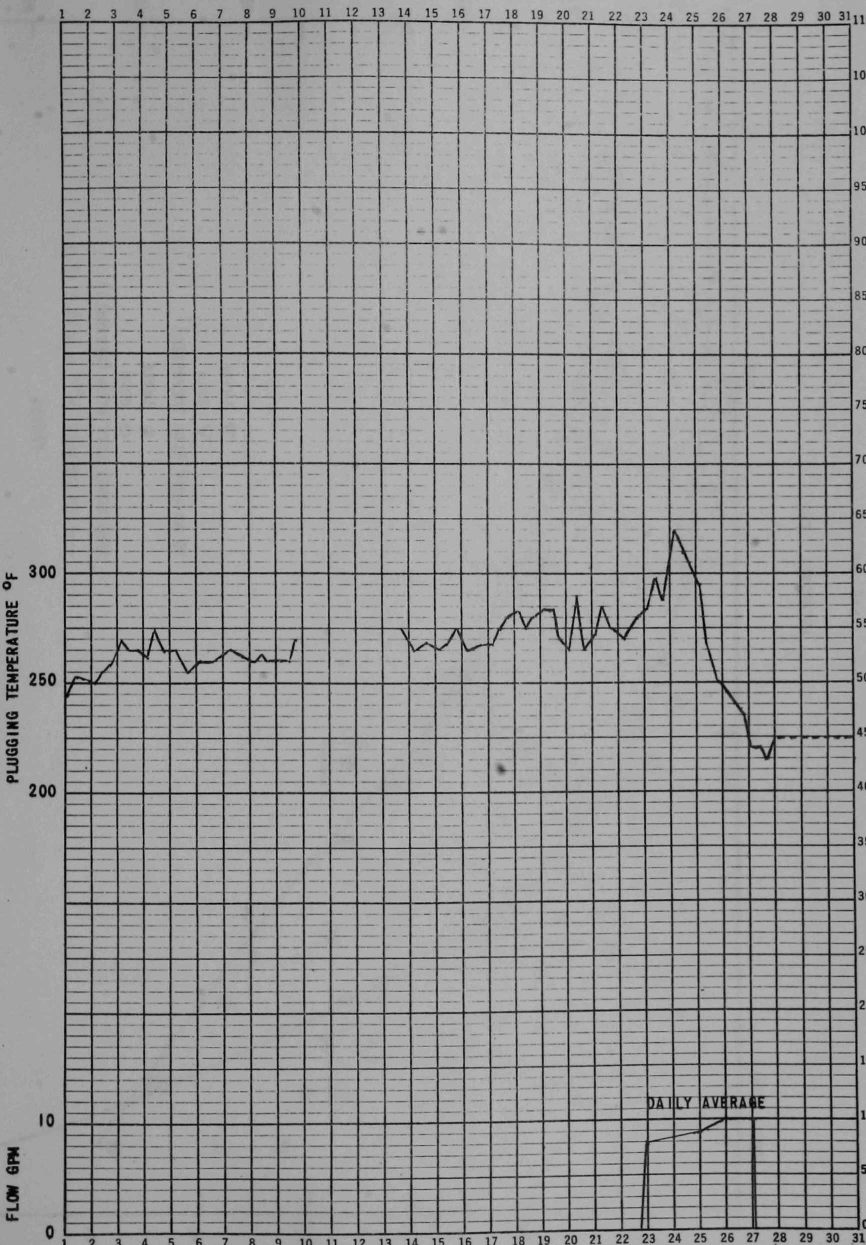
FIG. 35



SECONDARY PURIFICATION SYSTEM PLUGGING TEMPERATURE AND FLOW

Month NOVEMBER 19 66

FIG. 36



SECONDARY PURIFICATION SYSTEM PLUGGING TEMPERATURE AND FLOW

Month DECEMBER 19 66

FIG. 37

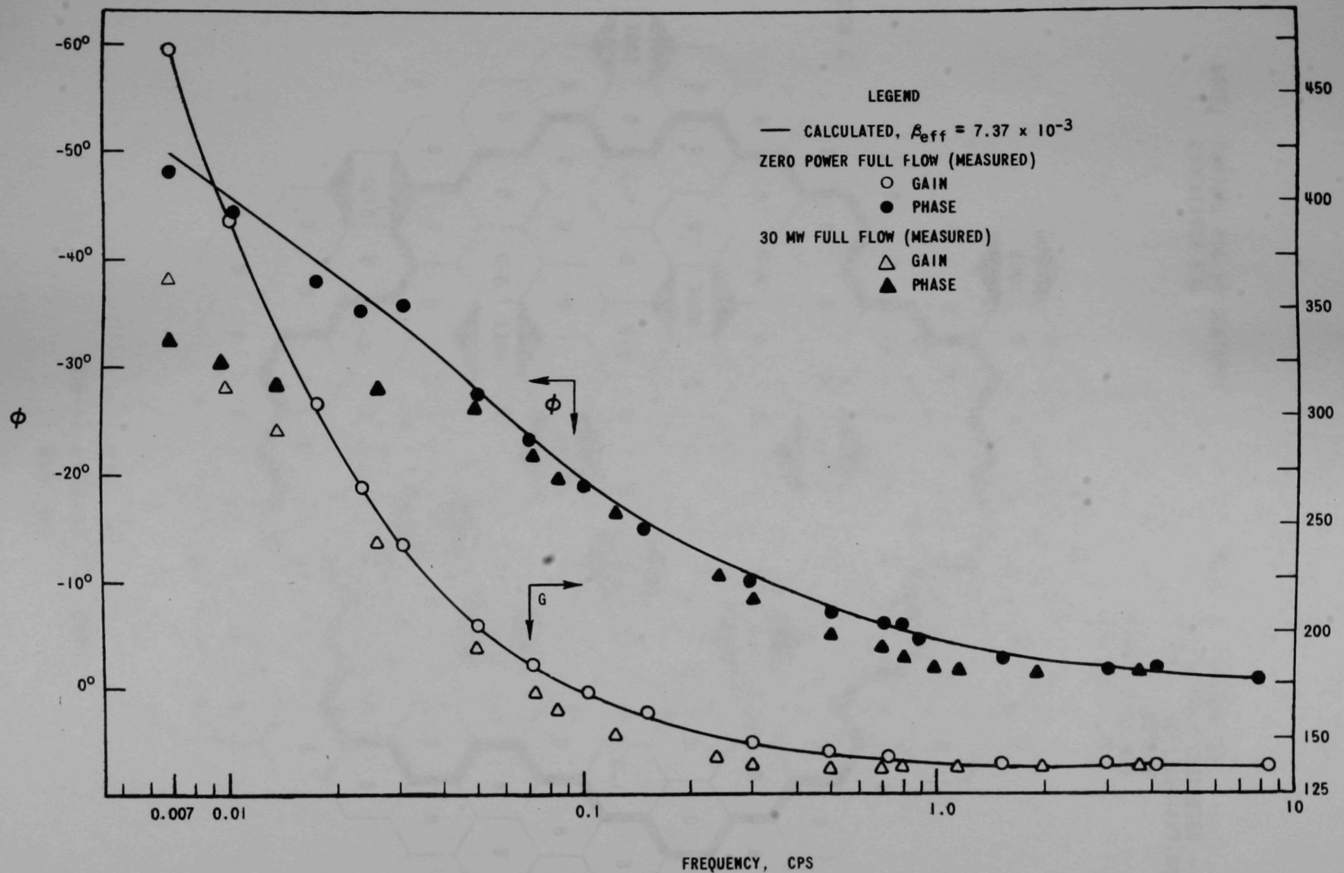


FIG. 38

EBR II TRANSFER FUNCTION

NOTE: CONTROL ROD #8 CONTAINS OSCILLATOR ROD

KEY:
- D DRIVER FUEL
- B BLANKET (DEPLETED - U)
- Be, Sb BERYLLIUM-ANTIMONY SOURCE
- C-# CONTROL ROD
- S-# SAFETY ROD

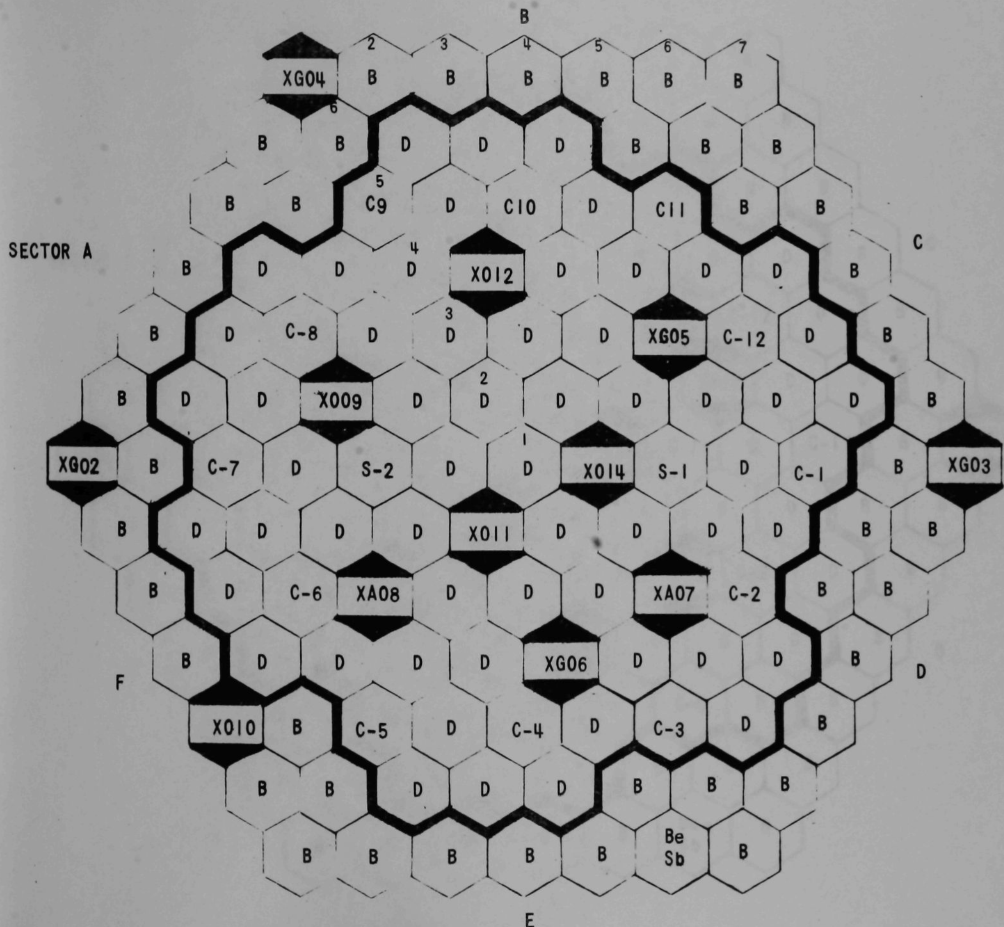


FIG. 39
EBR-II LOADING PATTERN
RUN #22

NOTE: CONTROL ROD #8 CONTAINS
OSCILLATOR ROD

KEY: D DRIVER FUEL
B BLANKET (DEPLETED - U)
Be,Sb BERYLLIUM - ANTIMONY SOURCE
C-# CONTROL ROD
S-# SAFETY ROD

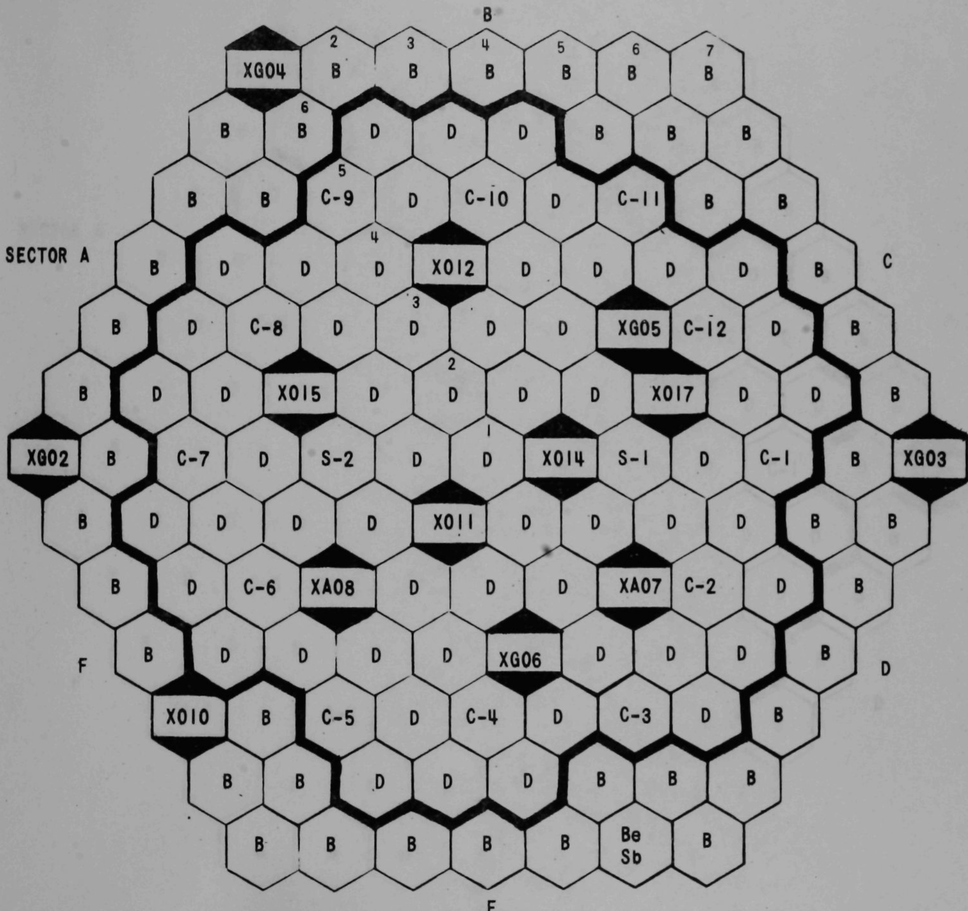


FIG. 40
EBR-II LOADING PATTERN
RUN #23

NOTE: CONTROL ROD #8 CONTAINS OSCILLATOR ROD

KEY:
D DRIVER FUEL
B BLANKET (DEPLETED - U)
Be,Sb BERYLLIUM - ANTIMONY SOURCE
C-# CONTROL ROD
S-# SAFETY ROD

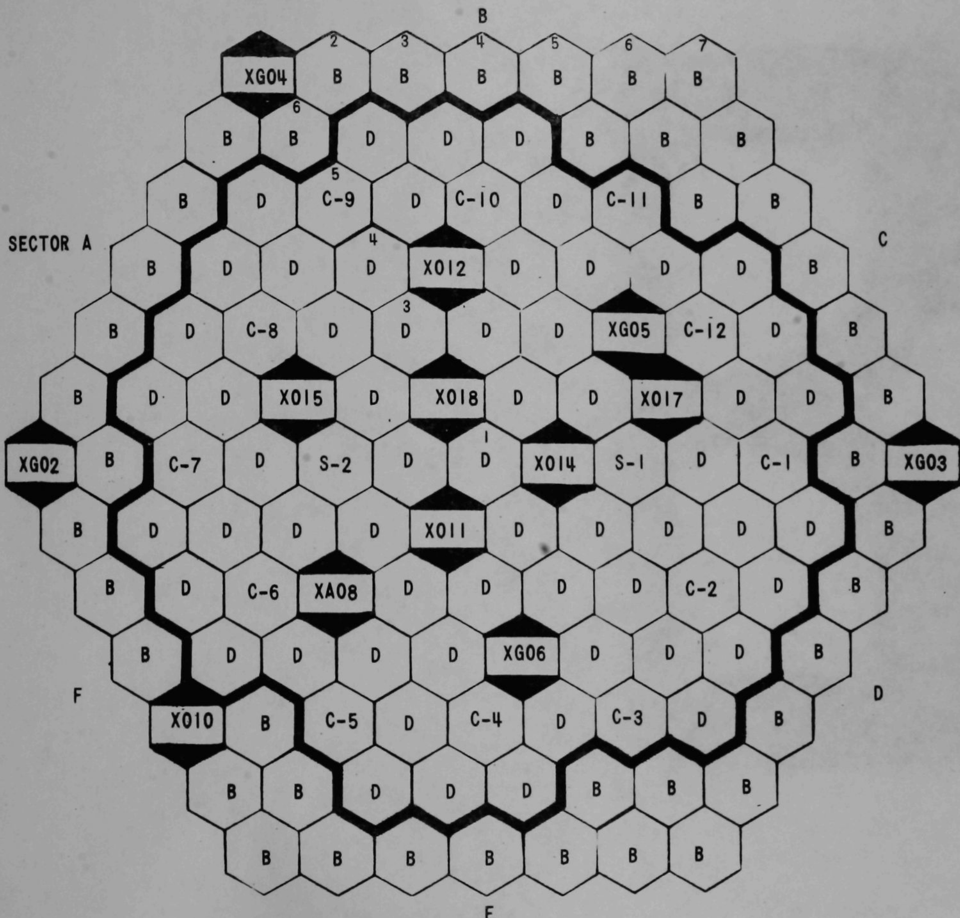


FIG. 41
EBR-II LOADING PATTERN
RUN #24